Understanding Site Offices Challenges to Communicate and Exchange Information Using Technology in UK: Main Contractor Perspective

Rasha Sayed Suleiman
School of Built Environment

The University of Salford

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Student ID @00276600

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I deeply appreciate everyone's belief in me.

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Abstract:

The construction industry is a complex, dynamic, fragmented environment that involves many stakeholders and, by being based on team collaboration, integrates various groups through the use of a range of systems. One of the major difficulties in the construction industry is to ensure that the correct information is available on site at the point of application. The global shift from paper-based documents and drawings to electronic-based files has tended to overload project teams with information. Currently, the work of site operatives still depends on the timely ability to access documents, paperwork, drawings and personal data together with the retrieval of relevant information. This creates a divergence between proven construction information and information on the building site itself, which can result in contradictions and misinformation.

The volume of information increases in parallel with the development of technology and this complexity puts the construction industry under pressure to keep pace with other industries. This is particularly evident at the construction stage, when actual construction activities are carried out and a huge amount of information needs to be exchanged. However, most research into, and development of, IT usage to support construction industry collaboration is largely technology driven (Wikforss & Löfgren, 2007). This has resulted in the failure of information communication technology (ICT) systems to adequately support construction operations (UKCES, 2015). Inadequately configured construction processes have, very often, resulted in the misalignment of technological deployment and construction processes (Martínez-Rojas, 2015). Moreover, the inappropriate use of technology could result in the creation of extra work for other on-site stakeholders. Therefore, an improved alignment between information, communicators and technologies through enhanced communication techniques for the profession should be considered in order to overcome the challenges of complex projects.

Studies have focused on effective and successful communication, and found that inefficient communication throughout the lifecycle of a project is one of the major causes of project failure in the construction industry. Many previous studies have addressed poor communication in construction; however, this study aims to:

- Identify the impact information and communications technology (ICT) on on-site construction operations
- Critically evaluate site office communication in order to identify which features have the most impact on construction site management; and

- Assess how the effective use of ICT can enhance site management efficiency.

Understanding the challenges that take place from the main contractor perspective helps to establish a set of recommendations that can improve the exchange of information between stakeholders, ease communication, and consider the use of technology to improve site office information flow. In other words, the purpose of this research is to understand how to improve site information management using technology through the perspective of effective communication.

1 Introduction

Construction projects are complex as they involve a broad range of participants, stakeholders, technologies and materials (Briesemeister, 2018). To manage the amount of information created over the life of a project, communication and information management systems have become increasingly important. (Pryke & Smyth, 2012). However, studies on communication and information management in construction focuses on the use of IT applications in a formal way to deliver information on site (Ejohwomu et al.,2017; Brandon et al, 2017). Even though many fields of research have examined the area of communication, there is still the need to reach a new understanding that considers the rapid and uncontrolled changes generated by construction management. This research investigates the understanding of gaps in, and challenges to, effective site office communication through the appropriate use of technology. It will develop a set of recommendations that consider the existing complexity of current communication methods.

1.1 Background to the study:

There has been a significant history of communication problems within the construction industry; these have included a lack of coordination and trust, and the separation of design from construction activities. Such problems have resulted in increased project costs and time (Akintoye & Main 2007; Egan, 1998; Latham, 1994; Wolestenholme, 2009). The interface between key specialists and site operatives is the main location of most problems that arise (Hackley, 2015). In order to deliver a buildable project that meets the requirements of the client, the professional transfer of relevant and appropriate information at all stages of the project should occur (Emmitt & Gorse, 2009). Thus, designs, drawings, information, specifications and methods of construction have to be communicated and understood by designers, contractors and operatives (Hatley & Pirbhai, 2013). Information is inextricably linked to activity; it enhances the ability to act, and the activity creates information. Consequently, information is an important element in the enhancement of any organisation process. Furthermore, Ball (2014) noted an increase in the amount of information required of site operatives during the construction process; such information tracks and updates both the design and project plan. Theoretically, before all the necessary ordering of materials and prior to the stakeholder engagement for the specific site operation, the details of the relevant components should be completed with sufficient time to revise, check, redraw and correctly specify (Gorse,

et al., 2007). Moreover, the failure to recognise that essential information is missing, conflicting or incorrect will result in delay, additional cost, and the adjustment of resources or plans (Heesom & Mahdjoubi, 2002).

During the last few decades, there has been increased demand for a wider set of useful functions in the construction industry. Multiple inputs from different specialised stakeholders are now required to manage complex and sophisticated activities (Shohet & Frydman, 2003). Thus, the project process coordinates activities among the task-oriented project team members (Dawood et al., 2002). One of the stakeholders in the project team controls and manages the functional tasks of the project process. The construction stage is a critical phase of a project when there is an increased need for all individual participants to process and understand information correctly and accurately in a timely manner, and from this basis, appropriate decisions can be made. Furthermore, for task implementation, stakeholders need to communicate a large amount of information that can be chaotic in nature (Dainty et al., 2007; Thomas et al., 1998). Thus, effective communication is essential between project participants in order to deliver successful projects, reduce conflict, undertake reworks, and enable reduction through the identification of lean waste (Koskela, 2004). However, effective communication among the project team members is complex and difficult to achieve. Many problems within the construction industry relate to poor communication, such as not receiving enough information, receiving information late, or difficulty in accessing information due to the complex combination of people, processes and organisational cultures.

The complex nature of the construction industry plays a major role in defining the project process. While in other manufacturing sectors, objects are wholly assembled from parts in the assembly process, in construction, the parts are too large and complicated to move through assembly stations. Therefore, the station moves through the stages of an emerging whole that add pieces with each movement; thus, construction projects are rooted in place. They are largely project-based and highly mobile, whilst the relationship with site operatives is different as operatives walk through the construction site during the production process (Ballard & Howell, 1998) (Figure 1-1). This rootedness brings differentiation that affects the way in which participants communicate and interact with the surrounding environment in order to achieve a successful project.

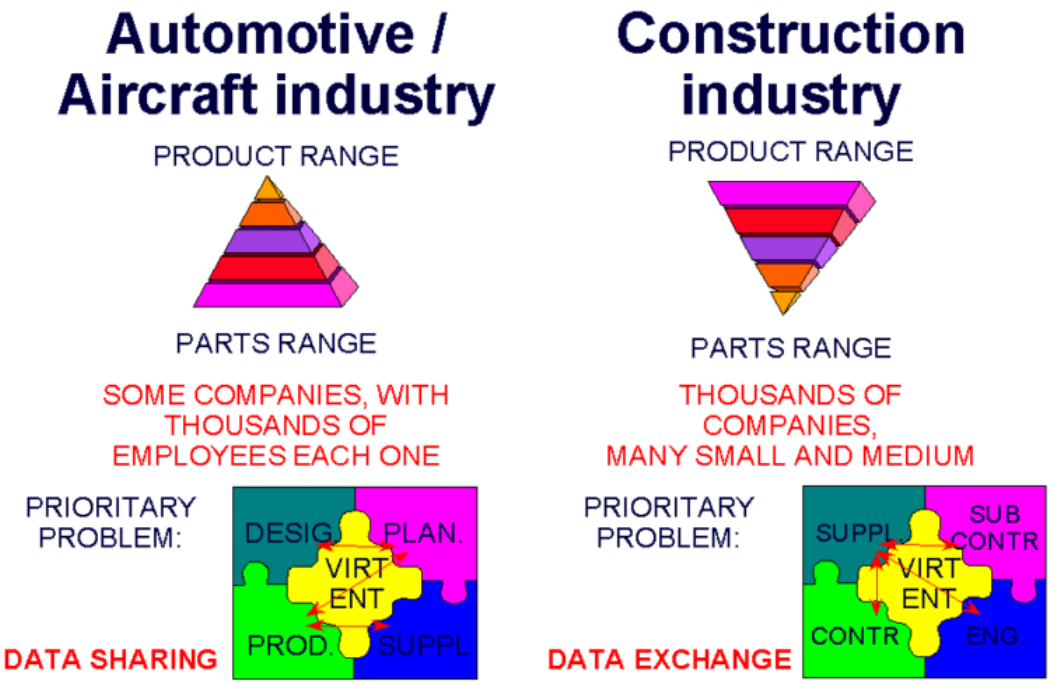


Figure 1-1 Comparison of the automotive and aircraft industry with the construction industry (Source: Grassi & Zorgno, 1999)

The complexity of stakeholder management influences the imposition of collaboration; this is partly due to the involvement of heterogeneous information and multidisciplinary teams (Chassiakos & Sakellaropoulos, 2008). The complexity of a construction project is directly reflected in a team's communication performance, and different sub-teams' understandings of the project goals and expectations (Wood, 2009). This complex project information and knowledge can lead to communication conflict between the project stakeholders (Dawood et al., 2002). As such, a method is needed to manage communication on a construction project site where a large number of parties need to work closely.

Several researchers have attempted to address collaboration between the construction project team across all disciplines. However, most suggestions to improve collaboration in the construction industry are based on technological solutions at the design stage of the project. These studies tend to neglect the link between technological solutions and the other aspects that affect communication. For example, Anumba et al. (2002) suggested an intelligent agent system to improve asynchronous communication between the construction parties. Shared, open web-based information was emphasised by Cheung et al. (2015) when developing collaborative design between construction team members. There needs to be an understanding

of people's reactions to new methods and technologies in order to understand the level at which technologies have been used and whether it is possible to use more developed technology. Although technical issues are important for improving the quality of projects, as these tend to be less effective if not considered in relation to other aspects. Thus, there is a need to identify and improve different aspects of project and information flow management.

Site management needs to consider that the involvement of many stakeholders in the construction process means that different parties require information at different times. Rezgui (2001) identified that the AEC (Architectural, Engineering, Construction) industry is information and knowledge intensive. The multidisciplinary, complex nature of the industry requires that all parties have a chance to communicate their experience and knowledge efficiently to other project stakeholders (Burger et al., 2015; Phelps, 2012; Shen, 1992). Various operatives will have conflicting knowledge about the building, whilst any unfamiliarity with the site conditions could result in different information requirements from the project. Thus, the way in which all stakeholders communicate with each other is key to the delivery of accurate information. The combination of the physical environment with the experience, knowledge and information of each party enables a greater understanding of effective communication (The National Archives, 2013). Furthermore, the key to successful communication requires communicators to have an informative intention that the receiver understands and recognises (Sperber & Wilson, 1986).

1.1.1 Research rationale:

Research has been conducted on construction projects to study the management and cooperation of construction information models (Walker, 2015). Most of these studies focus on the technical aspects associated with information management problems (Vick, 2015). Nevertheless, information management also concerns nontechnical elements, such as the methods of information exchange, how all parties are involved and communicate, and how the client and contractor coordinate with other stakeholders (Wood, 2009). Information quality has a critical role in determining the outcome in the construction business; thus, poor drawings and reports, either in the bidding or construction phases, can result in poor information and poor quality products (Cicimil, 2005). It is possible to reduce any rework and failure in the construction process through improving information quality by using appropriate methods and technology. This is particularly important in the pre-construction stage and during the construction works. According to BRE guidance (Building Research Establishment, 2015), every year in the

UK construction industry, defects cost at least £20 billion to repair or rebuild, and poor communication is cited one of the causes of these defects; For example, "operatives being given incorrect instructions or technical information not being available". (BRE, 2015). Poor communication accounts for an average of 15% of the losses in a construction project's value, which is usually worth more than £99 billion (ONS Construction Statistics, 2017). Furthermore, Client Confident (2018) calculated an estimated loss of up to £13 billion from poor communication between parties.

Therefore, the effects of construction activity on waste production are enormous; in 2012, the UK generated 200.0 million tonnes of waste, and half of this was generated by the construction sector (Government Statistical Service, 2016). Construction projects are site-based and require a higher level of information (Oesterreich & Teuteberg, 2016). Thus, the construction stage is the most critical phase when a large percentage of construction waste occurs; according to the Wrap Survey (2009), 60% of waste occurs during mobilisation and construction. In the construction stage, construction drawings, reports, specifications and other documentation need to communicate and document the contractor's work in terms of what and how to build. It is the contractor's responsibility to update and establish all construction related activities and documentation. Therefore, it is important to improve site management (Aziz et al., 2013). In addition, large volumes of information are generated during the building design process, and often time is wasted searching for, sharing and sometimes recreating information (Persson et al., 2009). It has been identified that ineffective communication is one of the fundamental components that contribute to the construction industry's poor performance. (Ajayi, 2016; Dainty et al., 2006). This research focuses on site offices as this is where construction activities and information exchange takes place.

For the past decade, inaccurate and untimely communication between project parties have led to costly delays and posed a significant challenge to the construction industry (Martínez-Rojas et al., 2015). The lack of timely accessible updates has caused a loss of information; according to Koskela (2004) waste occurs whenever tasks are started without the necessary information. Like other industries, the construction industry developed the use of technology to replace paperwork, which has made tasks easier and quicker. Furthermore, Smartphones have become widely used in the construction industry, particularly in countries such as Finland and Sweden (Samuelson, 2008), although they are still only partly used in the UK (IET, 2012). Thus, innovations have been used to improve the construction industry. Clients, engineers and

researchers seek to develop technology to change the future of construction; examples of this include photogrammetry, Google glass, mobile applications, tablets and a range of hard and software.

When faced with volumes of information, it is imperative that an appropriate method is adopted to implement technology to ensure maximum benefit within the industry. Millions have been spent on technology to plan and build safer and smarter projects; however, the full potential of the data remains unrealised, whilst accessing project information on site remains expensive, clumsy and slow (Garcia, 2012). It is important to identify how construction industry sites within the UK could integrate the use of technology to reduce the use of paper and increase productivity; this is one of the biggest challenges facing the industry (Hardin & McCool, 2015). The implementation of new techniques and practice needs to acknowledge sets of guidelines, frameworks, roadmaps, approaches, or success factors (Geraldi et al., 2011). This problem could be better addressed by effective communication that manages and delivers a large quantity of information by using the right techniques.

This research sought to identify how construction participants interact in construction site projects in order to understand the mechanisms of communication, technology and the environment of the construction site from the contractor's perspective. The obstacles to effective communication and the complete adoption of technology need to be identified, particularly from the perspective of the main contractor. This requires the analysis and categorisation of the result in a way that considers people and organisation management roles, and thus improves communication. A set of recommendations is needed for better communication in order to improve site management.

1.2 Aim:

The aim of this research is to understand how technology, as currently practised in UK construction site offices, is aligned with effective communication. It aims to identify ways to support the construction organisation in the rapid and successful implementation of effective communication using mobile technology. Therefore, the aim is to understand the obstacles, difficulties and challenges of communication amongst a project team in on-site offices from the main contractor's perspective when exchanging and communicating site information using mobile technology. The outcome of this research will be a set of recommendations that can be implemented through an appropriate framework to enhance effective communication on site

using technology. The thesis describes the application of a ‘communication protocol’ as a basis for evaluating and understanding the communication process of exchanging information.

1.3 Objectives:

- To understand the current communication practices and theories applied on construction sites.
- To investigate and identify aspects that help to improve communication and information management, including its access and delivery, according to the main contractor on construction sites.
- To explore the type of information and technology needed for on-site construction to ease effective communication.
- To explain the challenges to the establishment of effective communication that consider its complexity based on technology tools applied the UK.
- To synthesise the findings into a set of recommendations.

1.4 Research Questions:

- What are the current communication processes of on-site offices in the UK, including their limitations, challenges and benefits?
- What is the nature of any communication gap?
    - How is it linked to issues concerning information and communication technology?
    - What proportion of the problems relate to technology?
- How do the stakeholders involved collaborate to enable communication and information exchange?
- How could a complex construction environment reflect in the communication on site?
- How can construction site teams be supported in the rapid the use of technology, and mobile technology, in particular?

1.5 Research Scope:

The scope of the research is to improve communication within on-site construction projects. Specifically, the study investigates how the main contractor exchanges information and identifies the technology and techniques used for communication. By understanding both information and site management, this considers the complexity of the environment and helps to define existing communication challenges. Based on the literature review, the research found that effective communication on site is problematic and complex for many reasons, such as:

1. Participants who work on site (as individuals and organisations) are the main influences on any communication improvement. This considers: relationships, trust between the main contractor and subcontractor, people skills, behaviours, knowledge, organisation culture and management. All these facets can increase the gap between team members and impact on communication.
2. The information needed to complete the job involves; information technology, information management, an information system, availability, accessibility, currency, accuracy and a strategy to control the exchange and communication of information on site. The need for information could cause a delay or rework.
3. Although existing studies noted that multiple-technological options were identified on site, many are not used correctly. Thus, the use of technology for on site communication is still limited and potentially inappropriate.

To achieve the goal of this study, mixed methods were used; this entailed collaboration with two international contracting organisations in the UK to access data. These data are collected through a survey, which is used to align with the literature review. Following this, the observation of on-site offices and unstructured interviews were conducted in order to understand the current situation of on-site office communication. This stage focused on the following questions: how do individuals communicate, what tools do they use, and how do they collaborate to enable the successful exchange of information? The results of the research show that the use of technology to communicate within the site is less than the capability of that technology. This difference arises due to the presence of many limitations and obstacles, such as time, contract, cost, people and the management system. In order to validate the findings, the outcomes are compared with other research outcomes from the literature review, as well as with the survey and case study findings. The primary objective is to develop recommendations that could improve the quality of site operations using technology.

1.6 Methodology overview:

It has been observed that the success of every study depends strongly on the appropriateness of the research methodology and the methods used in the investigation. A research methodology explains how data are collected and analysed in order to achieve the aim of the research. It also identifies the influence of the philosophical stance of the research. The ontological position of this study is a combination of social constructivism and objectivism; it applies interpretivism to answer the research question. The choice of methodology lies at the centre of the research, and is linked to an inductive approach; thus, the strategy was built on previous information, which led to the selection of a qualitative approach, which was deemed most suitable for the study's aims and objectives. A qualitative approach informs the data collection; the researcher chose to collect case study data by observing two site offices managed by the main contractor in order to construct a particular project's building type. Interviews were used to support the observation results.

For this research, a case study strategy will explore representative examples of communication on site in order to extrapolate findings relevant to the wider situation within UK construction. This will seek to develop a new understanding of effective communication challenges in order to understand how the use of mobile technology is linked to communication on site. It will examine the collected data using a thematic approach and then compare the findings by triangulating the data.

The literature was reviewed following the first phase of data collection in order to develop a basic framework on which to construct the research. Thus, the primary data complements and updates the understanding of the literature review. The data for this phase of the study will be collected through questionnaires that help the researcher to understand the current situation concerning on-site communication. The questionnaire will focus on the information needed, including how to request and receive it; this will help to build a better understanding of the current communication culture and the flow of information on site. Observing the site office will enable the collection of further detailed data; these will be coded and analysed using thematic analysis. The recommendations of this study will be based on the findings concerning the communication and exchange of information on site using technology.

1.6.1 Research design:

The research design is illustrated in Figure 1-2 showing the different phases of the study.

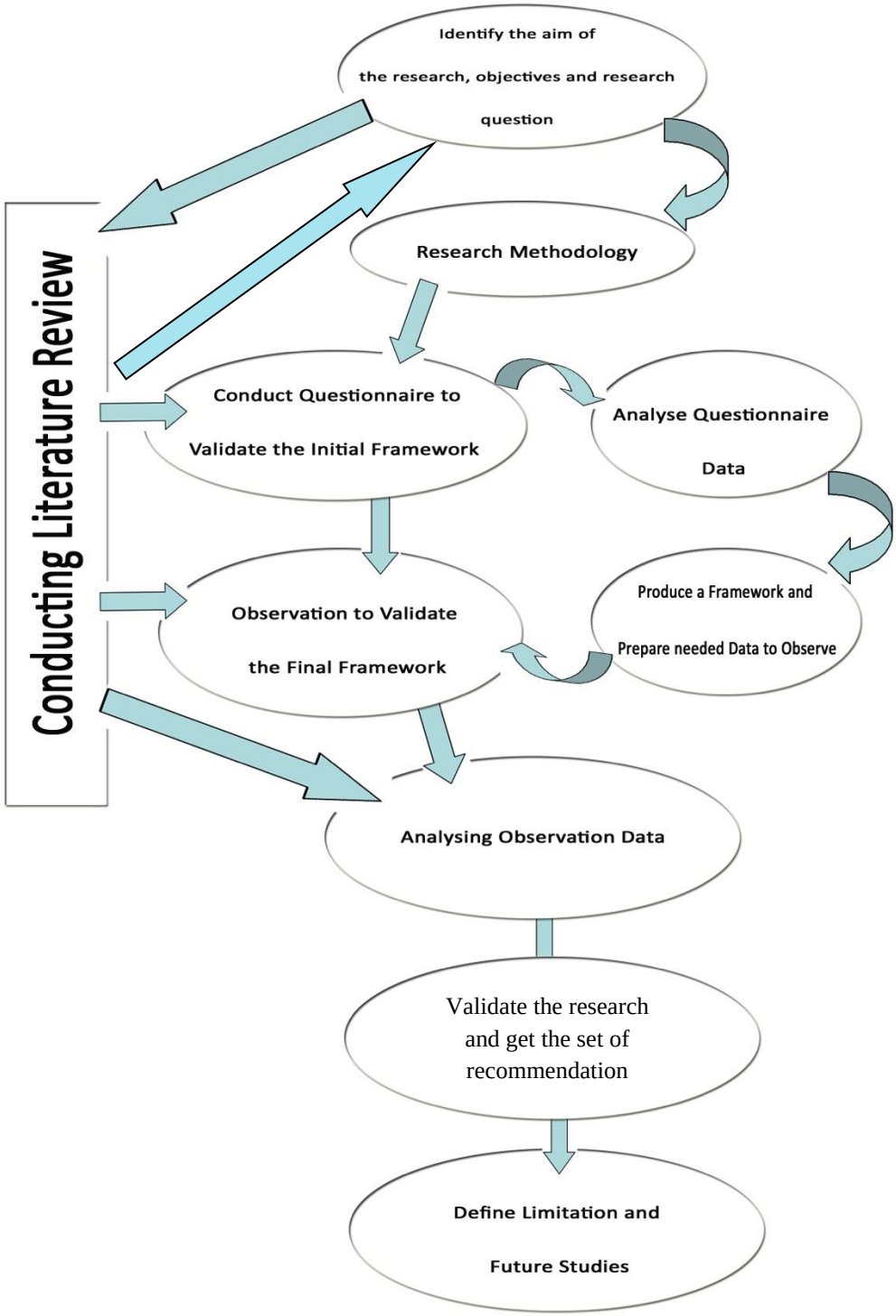


Figure 1-2 Research Design (Source: researcher's illustration)

1.7 Thesis structure:

Chapter one provided an introduction to the study. It set the scene for the thesis by providing a background to construction innovation. Furthermore, it presented the research aim, questions and objectives and explained how the researcher intends to address these facets. Chapter two reviews the communication and information flow in construction, and examines the process of communication in detail, including how it reflects on the delivery of the message. The chapter then explores the concepts of communication, which includes the communication media (both verbal or nonverbal), and the communication channel (both formal and informal). It considers the complexity of construction as a multiorganisation culture and the impact of this on the level of communication. The chapter reviews literature on effective communication in construction projects by examining the definition, need and use of effective communication to control the project information flow. Furthermore, the chapter outlines the barriers and challenges and the impact of: information type, the people who communicate, and their organisations. From this, chapter two builds an understanding of communication as a tool, and the need for effectiveness in complex environments, such as construction sites. Finally, the chapter outlines the challenges for the sector that need to be understood in more detail.

Chapter three provides a review of literature in relation to technology and construction. It describes the nature of the industry, and the importance of people in developing and maintaining effective communication. This chapter reviews the extent to which information is important and examines information communication technology, and the sharing and management of information. The chapter concludes by exploring the potential impact of technology and mobile communication technology as methods to improve site communication. Meanwhile, chapter four describes the research methodology applied and justifies the decisions made concerning its design. The underpinning philosophy is explained including its influence on the approach, design and specific methods adopted to collect the data. The researcher outlines the data collection and analysis methods, the credibility of the research, and the ethical considerations of the research.

In terms of the findings, chapter five presents and analyses the questionnaire data in order to develop the framework that also reflects the findings from the literature review. The questionnaire results enable a wider understanding of the current communication issues on construction sites, including the challenges and barriers to effective communication. Chapter six presents and analyses the observation and interview data, which are based on two case

studies, namely two main contractor site offices in the UK. The researcher examines each case separately and discusses issues related to communication and site management. This explores the exchange of information and the use of communication methods with the aim of understanding the key characteristics and challenges to effective communication on site among team members.

Finally, chapter seven provides the conclusions; it compares data from the literature review, questionnaire, observations and interviews in order to validate the results. This chapter considers the achievement of the aim and each objective identified in the introductory chapter. Finally, the limitations and suggestions for further research are outlined.

2 Literature Review

2.1 Introduction:

"*Communication is one of those everyday activities that are intertwined with all of human life so completely that we sometimes overlook its pervasiveness, importance and complexity."*
(Littlejohn & Foss, 2010).

The construction industry has been criticised for a lack of collaboration and poor communication, which many reports and studies have attributed to the need for effective communication (BRE, 2015; BSI, 2013; BSI, 2010; BSI, 2003; Egan, 1998; Latham, 1994). A 1990 government report by Latham and Egan provided a pivotal point to improve the UK construction industry. Furthermore, Egan (1998) stated that the inefficient means of communication of project information caused two-thirds of construction problems. Construction projects are fragmented and complex as they involve various participants, organisations, technologies and materials for a temporary period of time (Kagioglou et al., 2000). Moreover, Anumba et al. (1997) stated that the growth of project teams and roles have increased the complexity of communication networks; this has resulted in an increase in time and cost in addition to the inefficient exchange of information (BSI, 2010). Although all parties involved in the construction industry can address their respective responsibilities, the lack of integration between each stakeholder often results in communication problems. Murray et al. (2000) proposed the baseline of communication through contractual agreements that defined the relationships among parties; this include information sharing and a level of coordination in construction. Thus, to manage the increasing amounts of information created during the life of a project, communication and information management systems have become increasingly important (Chan et al., 2004).

This chapter addresses the first objective identified in chapter one, namely to enable a clear conceptual understanding of communication, communication processes and communication among participants in order to ensure a better appreciation of the communication barriers and methods. Moreover, it outlines how effective communication can improve the quality and productivity of projects.

2.2 Concept and definition of communication:

"… the essence of being human is this communicating to and being communicated with."

(Thayer, 1968)

A project's success and objectives could be achieved through effective communication (Clarke, 1999; Xie, 2010); however, this requires an appropriate understanding of communication. Communication is defined in various ways by different researchers. For example, Shannon and Weaver (1949) state that communication comprises all the procedures by which one mind may affect another, whilst Cheng et al. (2001) argue that communication is the act of transferring information from one place to another. Therefore, it is considered a 'complex process' (Sigband & Bell, 1989). It is also a process of sharing and understanding meaning and ideas (Arif et al., 2011), and a dynamic activity that keeps changing so it is hard to describe (Clark & Brennan, 1991). While some researchers emphasise the channels and media ued in the process of communication, others focus on communication as the skills of interaction. Understanding how to relate the knowledge that receivers have with the interpretation and perception of received information is at the core of communication, for sharing means and doing things together (Fiske, 2010; McLean, 2003; Ruben et al., 2016). McQuail (1984) described communication as a guide to control, power, change, interaction, relationships, exchange, community, and much more. It considers the exchange of facts or ideas between two sides (people or machines) as one of the most elusive organisational variables (Fiske, 2010; Xie et al., 2010). Moreover, communication is an exercise that enables people to influence others in order to bring about some changes in attitudes, relationships and motivation (Pugh, 2016).

In building projects, Orlikowski et al. (1994) considered communication a personal management skill. The communication process is about encoding and decoding the message between the sender and receiver. As such, it is the basic meaning through which team members interact with other project counterparts (Cheung, 2015). Emmitt and Gorse (2009) mentioned that the emphasis of communication in construction lies in processing information as meaning rather than in communication skills. Some researchers focus on the role of communication in construction to embrace the meaning of knowledge and information integration. The definition of communication in building projects, according to Fischer (1989), is the continuation and inter-disciplinary sharing of knowledge among the project parties to achieve the goal of the project.

2.2.1 The importance of communication in construction management:

According to Singh (2014), direct or indirect communication is involved in every construction based activity and function, such as leading, planning, organising or monitoring. The construction industry, over the years, has fallen way behind other industries in terms of communication. However, the main criticisms levelled at the industry are poor cross-disciplinary communication and its particularly fragmented nature (Aouad & Wafai, 2002; Gann, 2000). Despite this, there has been an emerging awareness of the importance of effective communication (Akintoye & Main, 2007; BSi, 2010; Constructing Excellence, 2004; Egan, 2002; Latham, 1994; ROADCON, 2003). Critical links among people, ideas and information have been developed as a communication process. The process required to ensure the timely and appropriate collection, generation, distribution, storage, retrieval and disposal of project information are the main concepts underpinning project communication management. The majority of a project manager's time is spent on communicating with their team members and other parties who are included in the project, either internally or externally (PMBOK, 2013).

According to Aalst and Hee (2004), today's society has become increasingly complex such that it is no longer possible to study its entirety, and the construction industry is no exception. Due to the growth of project sizes and the fragmentation of project teams and project roles, construction communication projects have become increasingly complex and ineffective (Anumba et al., 1997; Dainty et al., 2006; Emmitt & Gorse, 2006). Construction projects are generally considered a multi-organisation process that mostly depends on the exchange of complex project data and information (Wikforss & Lofgren, 2007); thus, the construction industry faces problems when communicating information. The nature of projects inhibits the development of good communication links, and this includes temporary project teams, the diversity of project members, and its one-off nature.

Furthermore, distributed work crucially needs communication (DeSanctis & Fulk, 1999). Various factors may affect the construction project process, such as technology, internal or external constraints, and inhibitors. These factors can result in changes that need communicating among project parties (Soibelman & Caldas, 2005). To increase effectiveness,

project communication has to change the relationship between the collaborators, including how they behave and perform, and what tasks they undertake (BRE, 2015). On-site project communication needs to exchange an immense amount of project-specific information in order to ensure a clear understanding between the sender and receiver and thus enable effective collaboration (Makore, 2016). This is more comprehensive than general communication (Dainty et al., 2007). Accurate and timely information should be provided to all stakeholders who need to prepare and share this information and their feedback in a variety of ways. This is key to successful project management; if project staff have a clear understanding of their tasks and how to achieve them, this can reduce the overall waste associated with repair and rebuild (Emmitt & Gorse, 2006).

According to BRE (2015) guidance, poor communication is one of the reasons why the UK construction industry loses at least £20 billion every year. Furthermore, improving communication to and around a construction site could reduce the occurrence of defects and increase the quality of a building. In the same context, efficiency in a building is proportional to the quality of relationships between stakeholders (Emmerson, 1962). Effective communication amongst stakeholders in construction projects can therefore lead to increased productivity, increased efficiency and improved quality (Arayici et al., 2012; Egan, 1998; Emmitt & Gorse, 2007; Latham, 1994).

Stakeholders' relationships could be based on co-operation and the sharing of information amongst all project parties to enable benefit for all (Egan, 2002). As such, the link between the quality of communication and the efficiency and effectiveness of the construction process suggests that improvements in communication are needed (Thomas et al., 1998). Effective communication within the building project team and between contractors, subcontractors and managers at all levels can lead to better outcomes for project problems (Walker, 2015). Ensuring better communication in very early stages of projects could also influence the quality of projects by enabling participants to become involved in decision-making (Emmitt & Gorse, 2006). According to Baiden et al. (2006), communication in construction can be summarised as follows:

- The transfer of knowledge, data, skills, information and technology (Cheng et al., 2001). This is essential in the construction industry, as a huge amount of information needs to be shared amongst many parties. It is essential to share experience, knowledge

and ideas, and to enable collaboration between operatives in order to increase productivity.

- There is a need to understand the needs of the workforce (Dainty et al., 2007) as most construction project participants have different backgrounds.

- Social skills (Emmitt & Gorse, 2006) are required to encourage effective interaction between people on construction projects, particularly as it is a labour-intensive industry despite the introduction of IT technology. Thus, a construction project is a system of human interactions that respect, collaborate, trust, learn and solve problems.

- The motivation of employees (Hargie, 2010) is required on construction sites. Emmitt and Grose (2009) emphasise that communication during the construction process helps individuals to gain a degree of trust that enables more effective work and the achievement of project goals.

- Achieving coordinated results means that communication needs to occur between individuals, groups and/or organisations (Baguley, 1994). Moreover, working on construction sites mean working as a team and cooperating with all specialists and parties to successfully deliver project objectives. This entails the use of two-way of communication (internal or external)

- A transactional process exchanges something between the participants involved (Eisenberg & Goodall, 1993). Having many parties involved on construction projects means that it is important to communicate in order to conduct a construction business.

Despite the availability of technology, it is first necessary to meet the needs of project parties to develop improved communication and data systems (Adriaanse & Voordijk, 2005). Although there has been a recent uptake of ICT within the construction industry, the traditional means of communication (using paper-based information) is still widely practiced in many projects; thus, paper-based communication is the main method to communicate with different stakeholders. The contractual nature of the industry is main reasons for this (Ballan, 2011; Howard & Bjork, 2008; Sommerville & Craig, 2006). The problems that exist in construction projects indicate the need to support effective communication and information exchange in construction projects in order to stay in business, compete in a challenging environment, and transfer information across projects (Dainty et al., 2007). Therefore, it is more important to

ensure a successful performance and to deliver the changes that can arise throughout building projects.

2.3 The process of information communication:

The first step to effective communication is to understand the way in which communication occurs. People use communication to gain control over their environment; as such, in a construction environment, effective communication can help to achieve a positive influence through ensuring greater control. Fiske (2010) summarised the two main approaches to understanding communication, namely the process method and the semiotic method.

2.3.1 Approach 1: The process method:

Communication is the process of obtaining, interpreting and distributing all relevant information to the persons who need it. Kerzner (2013) states that communication is the lifeblood of a project and essential to more than one practitioner. Project teams, therefore, need to share, collaborate, collect and integrate information to achieve a project's objectives. As such, the understanding of the communication process is essential. Dainty et al. (2007) and Emmitt and Gorse (2006) argued that the process considers communication as the message transmission (through a channel) between two sides (transmitter/sender and receiver, which could be a person or organisation) when each seeks to influence the behaviour of the other (Steyn, 2012). The message flow starts from the sender, who encodes the message through the communication channel/medium as a verbal or non-verbal method, and ends with the receiver, who decodes that message. The outcome of a communication process is to check if the measurement points of successful communication prevent misunderstanding (Van der Walt et al., 1996). During the message process, noise and barriers will increase the difficulties in sending and/or receiving the message. Successful communication is thus dependent on delivering an understandable message to the receiver. (Burke, 2007); if it is less than expected, it is viewed as a failure. As such, the key concern of the process is how to:

- Encode and decode the messages from both sender and receiver;
- Transmit messages via communication channels;
- Determine the accuracy and efficiency of the communication act.

Figure 2-1 illustrates the communication process described by Van Staden et al. (2002:13). It shows how communication originates from one individual or organisation to another

conveying information via a communication channel, and traversing all possible noise and barriers that could interrupt the message.

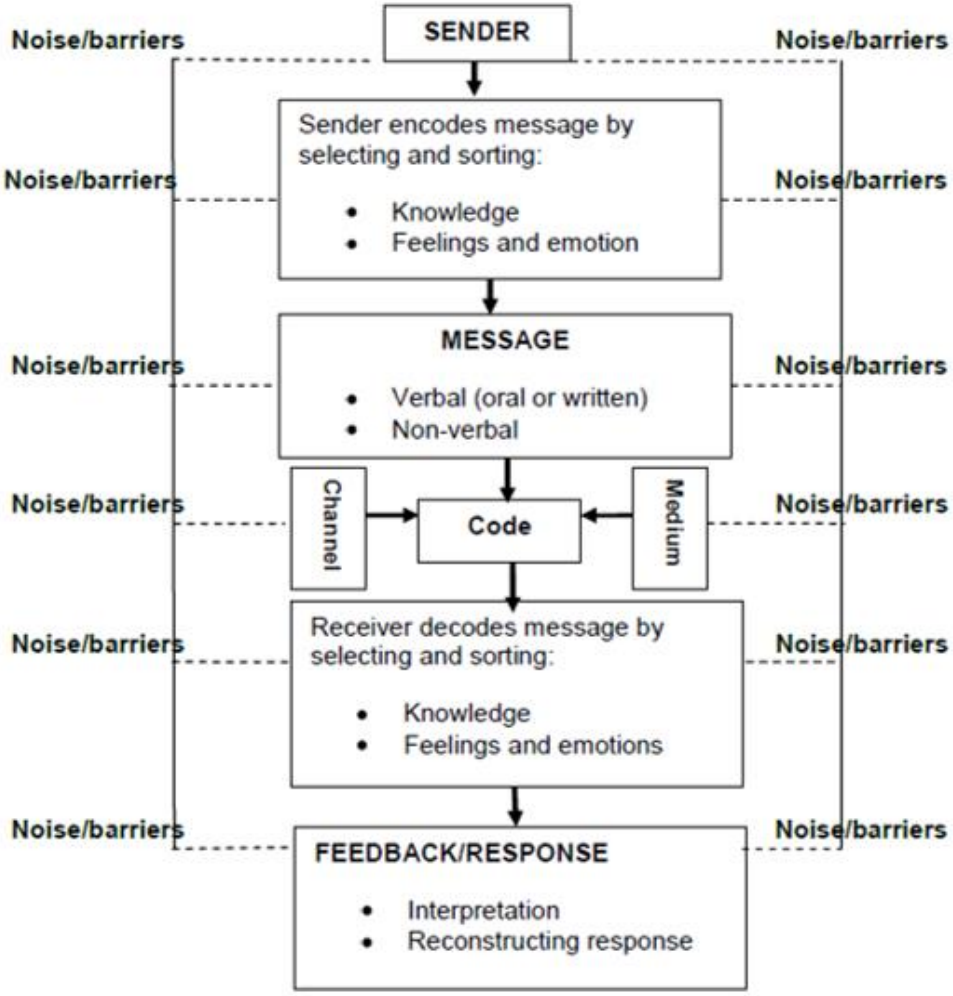


Figure 1-2 The Communication Process (Source: Van Staden et al., 2002, p.13)

Emmitt and Gorse (2006) defined the main elements of the communication process related to the construction environment as follows:

- **The sender**

Communication begins with the sender; this is the person who transmits an idea, thought or signal, which is then encoded into a suitable communication medium that could be understandable by both sender and receiver and can incorporate words, drawings and gestures (Emmitt & Gorse, 2009). The sender is the source initiating the communication (Thomas et al., 1998). Information selected for transmission and the media chosen by the sender may not always be understandable for the receiver so there is the potential for misunderstanding. The sender should aim to ensure all receivers can access and receive information (Hollingsworth,

1986). Although the sender should try to anticipate the receiver's needs, this does not always occur, as the sender could prepare contract documentation for subcontractors before knowing who will use it (Emmitt & Gorse, 2006).

In construction, communication roles between building project participants could involve many stakeholder professionals, such as the client, the engineering consultant, the architect, the main contractor, the subcontractors, and others (Eisenberg et al., 1993). The communicator could be an individual, organisational representative or an entire organisation. In construction projects, the communicator could adopt one of several roles, such as manager, site foreman, discipline engineer or professional firms (Thomas, 1996). The main roles for communication on site could entail: requesting information, sending information, asking questions, giving instructions, building teams or networking (Burke, 2007).

- **The message**

The message is a transmitted, encoded idea that travels through a suitable communication channel using a suitable communication medium (Dainty et al., 2007). This message could range from a simple drawing to confirm dimensions through to complex construction details that require drawings, letters and specification notes. Harrington (1991) stated that the information or message could be viewed in two different ways - as a resource or perception. The classic view of a message is as a 'resource', which means that information has been created, transmitted, stored and received by an organisation in the same way as the production of an assembly line. In such cases, the information is stable, static and unchanging. In contrast, 'perception' means that the information is more likely to be dynamic and constantly evolving; furthermore, it could be interpreted differently according to the receiver.

The main purpose of the message is to ensure the sender and receiver have the same full understanding; however, this is almost impossible as they both have different knowledge and experiences (Emmitt & Gorse, 2006). Some researchers define information in terms of its functions, which refers to the reasons why messages are sent and received in an organisation. Farace (1977) considered three types of information, which are production, innovation and maintenance. Furthermore, he clarifies that production information represents the messages that entail getting the work done, whilst innovation messages deal with problem solving, and maintenance involves the information used to solve personal problems and control institutional

issues. This classification of information influences the communication functions, namely transmitting information, coordinating work, and maintaining relationships.

According to the classification of information and the range of communication purposes, the information processes are divided into two types; formal and informal. These are used as channels for communicating information between project participants (Pietroforte, 1999). To transmit product information among the project parties, the message may be coded into different formats, such as formal letters, memos or drawings. The structure and importance of the message and the delivery channel control the form considered most appropriate for use (Bowen & Edwards, 1996).

In a construction project, information is often complex; thus, Pietroforte (1999) suggests that information could be communicated in two different ways among the collaborative project participants. Information used to represent the building needs to be realised, and information coordinating the activities leads to the realisation of information. BT (1995) outlined the most commonly used information classifications within the construction industry. As such, construction information is considered within three broad categories:

1. Firstly, technical information includes the designs and technical evaluations required to describe a building, such as specifications, details, drawings and design clarifications.
2. Secondly, commercial information includes the contract details that control and establish the responsibilities for delivering the project such as the delivery schedule, payment schedule and costs, conditions and administration information.
3. Finally, management information describes the information needed to control the project, such as the status of the contract, health and safety information, daily controls and schedules, and requests for information.

Therefore, the main aim in understanding the different project information types is to help to select an appropriate communication channel and media. Thus, the receiver is able to understand the meaning of the message.

- **The receiver**

The receiver will have decoded the message into meaningful ideas. Thus, the understanding of the message conveyed is based on the receiver's perception and understanding of the information provided at a particular point in time (Emmitt & Gorse, 2009). The interpretation of the message could vary among different receivers depending on their background and

knowledge. Sometimes the meaning that the sender includes in the message may be distorted when the receiver attempts to make sense of it. In a worst-case scenario, shared messages between the sender and receiver may never be understood; at best, the receiver may need more detail in order to ensure a full understanding of the meaning (Dainty et al., 2006). The receiver could focus on the information that helps to achieve the specific task; this selective attention could mean missing important information if the message is not presented in a clear and careful way that captures the receiver's attention. Aspects that will affect the receiver's efforts to process the information and understand the message will depend on the receiver. This includes the expected information, whether this information will affect the receiver, the knowledge of the receiver concerning the information, the ability to recognise when information is missing, the ability to request further information, the relationship and trust between the sender and receiver, and the ability to identify the importance of the message (McKay et al., 2009). The receiver's background includes their abilities, interests, attitudes, experience, knowledge and culture. These could influence the way receivers understand the message. Thus, communication media and the environment impact on the ability of receivers to understand the meaning of the message (Thomas, 1996).

- **The feedback**

In the majority of cases, there is an opportunity for the message receiver to ask the sender for more information or clarification. This is referred to as feedback in the communication models. In face-to-face interaction, communication and feedback signals are simultaneously exchanged (Grose, 2009). Feedback is essential to reflect the receiver's understanding of the message, and this can be verbal or non-verbal; however, it is important to complete the communication process.

In construction projects, professional organisations are mainly involved in the communication roles as senders and receivers. This includes the client, architect, engineering consultant, main contractor, subcontractor, and others. In a building project, the communicators could be the construction job site foreman, entire professional firms, or the lead discipline engineers and managers (Thomas, 1996). According to Eisenberg et al. (1993) communicators could be positioned at one of the three inter-organisation linkage levels: institutional linkages, representative linkages and personal linkages.

The basic process models are considered limited in construction projects where the communication among the project team is a dynamic process and characterised by multi-

organisational communication. In real projects, the communication process is more complex than those in models (Pietroforte, 1999). Thus, it is argued that the components of the process models may be multiplied to reflect communication in the building process. During the project lifecycle, changes could affect the team members as some could join and leave the team, whilst others could be trained or gain further experience. Thus, new communication channels could be created and fade away (Thomas, 1996).

- **Barriers and noise**

During the communication process, the effectiveness of communication between the project manager and other parties is influenced and affected by noise and barriers. Thus, inadequately cleared tasks and processes, and uncertain responsibilities or objectives might lead to failure in the project. However, the uniqueness in attitude, appearance, personality and behaviour of the person influences the way a person communicates (Knapp, 2013).

2.3.2 Approach 2: Semiotics

Emmitt and Gorse (2006) stated that semiotics consider communication as the production and exchange of meaning. Semiotics are mostly concerned with the way that messages are used to manifest meaning. The main difference between the process and semiotic schools of thought is the different attributions to the misunderstanding of messages. The semiotic school attributes this to a difference in culture rather than a failure in communication. The language of this approach highlights the importance of signs and meaning. Semiotic concerns are:

- The information, meaning and feeling that people could share;
- The nonverbal and verbal messages that are produced and exchanged;
- That receivers are affected by the message.

In construction, the information communicated needs to be timely and accurate; this could ensure the communication process is more useful to the project (Engeström & Middleton, 1998). To understand the information communication process, a suitable model would be required.

2.4 Channels for the transmission of messages:

The information is transmitted over a channel, which links the sender to the receiver. Grose et al. (2006) and Wikforss (2007) explained that people tend to communicate in two ways, either formally or informally. Formal communication is about contractual requirements, whereas

informal communication is conducted outside of such requirements (Figure 2-1). Emmitt and Gorse (2007) stated that uncertainty and the interdependence of different pieces of information form the communication and information flow. Communication channels are used to achieve and maintain relationships between the sender and receiver in order to exchange information and link between human behaviour and management.

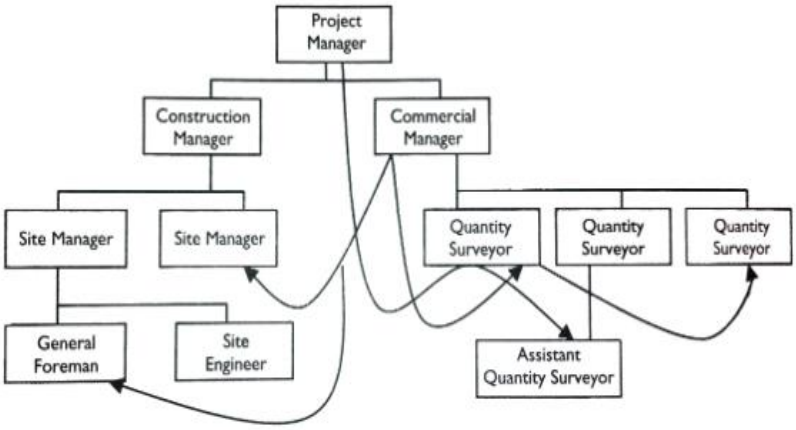


Figure 2-1 Formal and informal communication: hierarchy is formal (Source: Dainty et al., 2006)

2.4.1 Formal communication:

Formal communication is usually controlled by organisational roles or structures and by the contract; contractual forms or procurement strategies control the rules and preconceived ideas concerning communication (Dainty et al., 2006; Shohet & Frydman, 2003; Thomas et al., 1996). Formal communication is redesigned and applied to project teams to ensure they are involved, such as arranged meetings and management systems. Formal communication is dependent on accepting the communication system in the organisation, whilst formal channels are more likely to deliver downward instructions and directives in a written form (Xie, 2010), for example, drawings, schedules, change orders, the contract, and policies (Grose et al., 2003). Similarly, Dainty et al. (2006) mentioned that the source of information for formal communication follows an organisational hierarchy - vertical or horizontal (as shown in Figure 2-2). This controls the documents in accordance with the organisation's communication strategy. Managers' structured and organised channels, as well as events and systems, ensure that essential information is handled and recorded for future reference. Formal communication

is therefore normally explained according to the direction of movement, which depends on the organisational systems (Grose et al., 2003).

Anzalone (2000) stated that coping with changes that occur during a project lifecycle could make construction difficult; this is particularly true in a complex project, such as construction projects. In such situations, when formal communication lacks the ability to cope with need, informal communication could help to build bridges that cover communication gaps (Wikforss, 2007).

2.4.2 Informal communication:

Informal communication channels are methods of communication that are not directly controlled by organisational systems. Informal communication includes unstructured systems and does not follow authoritarian lines (Dainty et al., 2006). They occur naturally through friendships or contacts between people who are open to working together in a collaborative environment. Informal communication provides shortcuts or an unofficial way of requesting and receiving information, which helps to encourage communication between a project team and strengthens the information relationship (Chinowsky, 2012). Engeström and Middleton (1998) found that arguments and discussions that take place through informal communication enable better understanding which improves the coordination of activities and allows the team to maintain up-to-date knowledge in order to resolve unexpected problems. Similarly, Dainty et al. (2006) state that informal communication is important to complete tasks and enable project success without major delay.

In construction projects, contracts define the formal communication channel among participants. The contracts usually focus on the hierarchical relations between the project team members by establishing formal linages and a linear chain of command for information flow during the project. Communication through formal channels is generally slow, through a contract-driven process (Welch & Jackson, 2007). In comparison, informal channels are mostly used to request information and discussion is employed to solve problems, for example, face-to-face discussion, call conversations and workshops are not necessarily documented.

2.5 Communication media:

Communication can also take place without words but by the human senses, which are auditory, visual, tactile and olfactory (McKay et al., 2009). Communication skills will differ

depending on the way that communication takes place. There are two main types of communication that could be used;

2.5.1 Verbal communication:

Verbal communication depends on the exchange of ideas, thoughts or information through oral or written words, which could be face-to-face, through any device, by letter, drawing, and email. Oral communication is considered the most effective communication media (Emmitt & Gorse, 2009). The absence of any permanent record of communication is one of the important disadvantages that oral communication suffers from. This makes oral communication time-consuming unless there is a written summary or report, such as meeting notes and conference reports (McKay et al., 2009).

Written communication, using words, graphs, diagrams, pictures or drawings, may take the form of letters, emails, and drawing notes. Written communication is a formal version of communication. It possesses the capacity to store communication for future reference and can take place between distantly placed participants. Written communication is considered time-consuming because of the time needed to prepare and understand the message, whilst ensuring a minimal chance misunderstanding (Emmitt & Gorse, 2009).

2.5.2 Non-verbal communication:

Non-verbal communication has the significant capability to convey the message and provide judgments about communicators. The same messages could have totally different meanings using verbal or non-verbal skills, as vocal, facial and bodily behaviour have the power to change the meaning of the verbal statement (Burgoon et al., 2016). Non-verbal messages can be ambiguous compared to verbal messages; most of the time, they are not straightforward to understand. To improve one's ability to communicate, it is important to develop an awareness of non-verbal behaviour. According to Burgoon et al. (2016), some forms of non-verbal communication are:

- Facial expressions and eye gaze: these provide the main source of emotional information. However, culture can influence any understanding and reading of this method of communication.

- Posture and gestures: can be used to communicate a clear message, and help to identify people in agreement during a work meeting.

- Voice or para-linguistics: could refer to many features, such as articulation, volume, and speech rate, which could deliver a great deal of information and change the meaning of a message.

- Personal space and distance: can be instrumental in reflecting attitudes, indicating the balance of power and the creation of a feeling.

- Personal appearance: plays an important role in how the message that a person sends or receives could be interpreted and understood.

It is therefore essential to pick communication methods that could add value and deliver the right message or information, including whether a mix of verbal and non-verbal communication could be involved.

2.6 Level of communication:

Individuals and organisations use communication to achieve their objectives by forming a link between human behaviour and management, or management through communication (Yates, 1994). Communication plays the main role in achieving effectiveness in an organisation; therefore, it is important to understand the levels of communication involved. These could be divided into four levels (Gorse et al., 2006):

- *Intrapersonal communication* or intra-communication refers to the thinking process that takes place within and to the self. It is a root element of the decision-making process. Intra-communication is the level where the data has been processed for encoding when a message is sent, decoded and processed. (Burgoon et al., 2016).

- *Interpersonal communication* is a direct and basic interaction that takes place between individuals. Mostly, it refers to face-to-face communication, including verbal and visual interactions, which could occur through physical face-to-face communication or extended through virtual face-to-face interaction by telephone, letter, email, drawing and social media (Singh, 2014). Interpersonal communication is influenced by individuals' behaviours, thoughts and knowledge.

- *Small group communication* is when a group of people work together to manage activities. An individual's communication skills are essential when communicating within a group; additionally, the authority and power of the group have an effect on the

structure of communication. Group communication is an extension of interpersonal communication (Emmitt & Gorse, 2009).

- *Multi-group communication* takes place between different work groups in order to coordinate the efforts to achieve a successful project, such as communication with suppliers and subcontractors. It is essential to have the ability to work within a team to share knowledge and experience (Emmitt & Gorse, 2009).

2.7 Effective communication:

Sharing information and interaction during the project process includes problem-solving and decision-making. This needs to be supported by tools and technologies that influence the process of communication and knowledge creation. Encouraging individuals to learn and improve leads to an increase in their knowledge; this, in turn, can reflect on the organisation and result in effective communication, which positively influences decision-making (Singh, 2014). Business, people and technology are strategic elements in achieving effective communication (Chinowsky, 2012). Bouchlaghem (2012) determined that one of the main objectives of communication is the efficient use of the information resources of all stakeholders. Adopting changing relationships between collaborators, changes in the tasks they perform, and changes in contexts would be more effective (Anzalone, 2000). To achieve effective communication, trusting relationships should be built between all stakeholders, which enable them to work in new ways to achieve the project goals and objectives (Bouchlaghem, 2012). The effectiveness of communication depends on the degree to which the aims of communication are met; the aim in construction site communication is to facilitate the exchange of information among the team in order to complete the job effectively.

Guevara and Boyer (1981) claimed that the main aim behind organisations' communication is to ensure that all the participants who need it hold accurate information. Similarly, Schwalbe (2015) stated that timely access to key project information should be appropriately accessible to all the members of the project team, and that this is considered the main aim of communication. Understanding the concepts of effective communication help to define difficulties, improve exchanges, and enhance the quality of the project team; however, effectiveness in communication is not easy to achieve.

PMBOK (2013) identify that most project time is spent on communicating between project stakeholders, project managers and team members. Effective communication could create bridges that link stakeholders from different cultures and backgrounds who possess diverse experiences and interests. Factors like uncertainty, risk, deadlines, budgets, uniqueness, schedules and health and safety regulations increase the complexity of project management. The requirements of different project participants increase the need for effective communication management. To plan for effective communication management, there is a need to understand what a project requires from its communication system and the most appropriate communication methods and styles (Steyn, 2012). PMBOK (2013) illustrates the processes to manage project communication, which are provided in Figure 2-2 and detailed as follows;

- Plan communications management,
- Manage communications,
- Control communications.

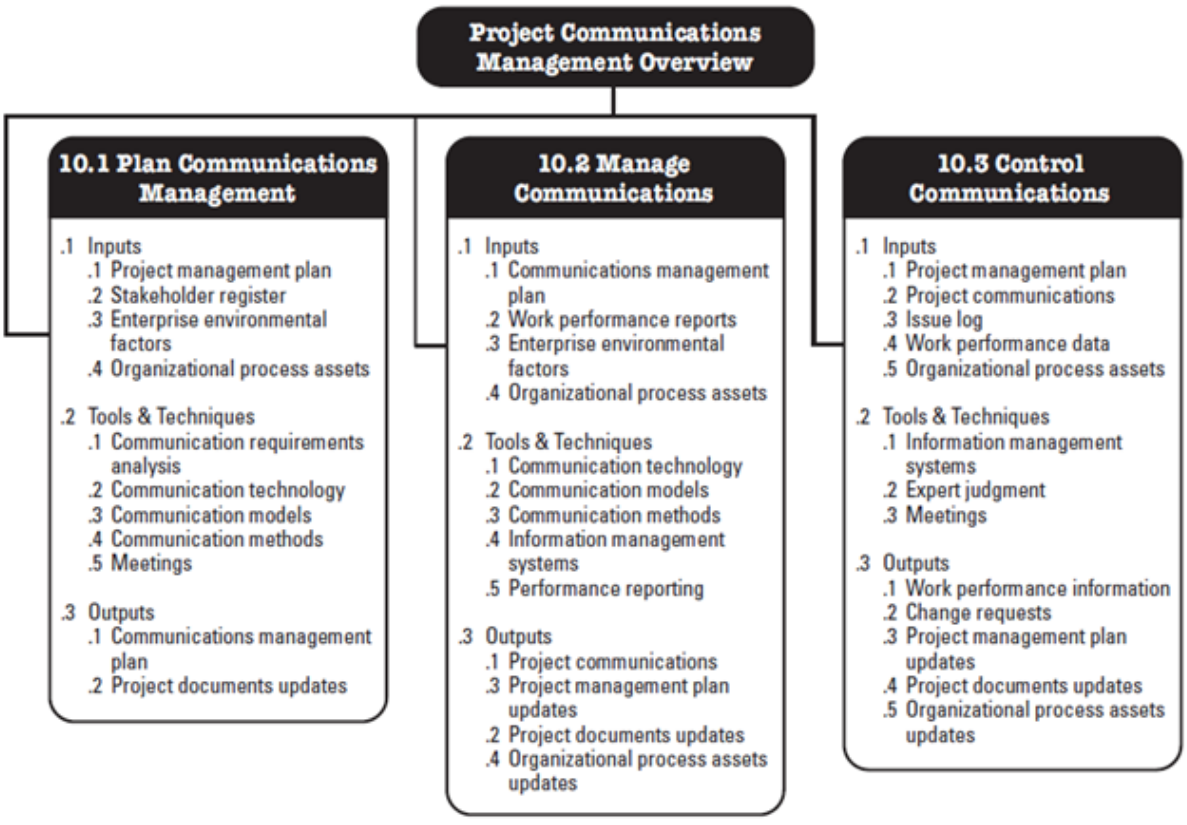


Figure 2-2 Project communication management overview (Source: PMBOK, 2013)

The main points outlined in the communication plan are:

- Who needs what information, and who [is] authorized to access that information.

- When they will need the information.
- Where the information should be stored.
- What format the information should be stored in.
- How the information can be retrieved; and
- Whether time zone, language barriers, and cross-cultural consideration need to be taken into account.

An inadequate communication plan could lead to delays, the delivery of the wrong message to the wrong people or misinterpretations of the message. Therefore, it is important to ensure the plan is produced on time and on budget to provide information in right format, to the right audience, at right time and with the right impact. It should focus on keeping stakeholders informed of the project's progress by making it visible at all times (Burke et al., 2010).

2.7.1 Effective communication barriers and challenges:

Many researchers have studied communication problems in the field of construction. For example, Guevara and Boyer (1981) highlighted four variables of the causes of poor communication in construction projects, which are overload, underload, gatekeeping and distortion. They attributed communication problems to prevalent issues with the information flow. In comparison, other researchers linked communication problems with project team communication. For example, Thomas et al. (1998) identified six critical variables of communication in a USA project, which were: accuracy, timelines, procedures, understanding, barriers and completeness. In comparison, Garton et al., (1997) focused on the effect of social networking, where, in a complex organisational communication network, role and centrality are considered the key variables. Furthermore, Murray et al. (2000) indicated that these variables were also critical for the UK construction industry. Research has also been conducted in the UK to understand communication in construction (Xie et al, 2003); such studies found that the procurement route significantly affected the communication process, especially for external communication. Those studies highlighted the need for effective communication in the construction industry.

Dawood et al. (2002) found that an increased number of organisations involved in construction projects resulted in a parallel increase in the information produced and in communication problems. They identified ambiguity and inconsistency as the most common problem in the exchange of information. Communication involves many tasks that need interactions amongst

project participants. This depends on the exchange of information across the organisation's parties, which could result in potential difficulties and challenges. These are usually experienced as (Dainty, 2007; McKay et al., 2009; Yang et al., 2011);

- A lack of efficient and effective tools for the exchange and organisation of the project information.
- Different organisations participating on the same project, which could make communication complex due to the different information input requirements amongst the parties.
- A lack of awareness of all participants' ethical, social and technological contexts.
- A lack of consistency in collaborative support.
- Time and data loss through information exchange.
- The lack of negotiation skills and knowledge needed to make decisions.
- Misunderstandings due to ill-defined information
- Non-cohesively structured project teams.

Communication boundaries are vital for recognising barriers and in identifying strategies to overcome them. Emmitt and Gorse (2009) highlighted organisations, contracts, projects, construction phases, team structure, professional groups and internal/user groups as the main boundaries for communication.

Communication is a complex process; sometimes the receiving message will not be same as the sending message. Sometimes, the message could be lost, not received at all and/or received incompletely, inaccurately or at the wrong time (Singh, 2014). Distortion is one of the four main problems that Guevara and Boyer (1981) defined, whilst the other three are gatekeeping, and the overload or underload of information. The UK construction has witnessed many reports that have berated the industry for ineffective internal and external communication (Baguley, 1994; Dainty et al., 2006; Latham, 1994; McKay et al., 2009; Wolstenholme, 2009). Gillard and Johansen (2004) clarified that barriers and noise could impact the communication process. Process communication barriers might be classified as:

- Physical barriers: a lack of privacy in an office, call interruptions.
- Physiological barriers: physical disability and discomfort, poor health.
- Psychological barriers: anger, fear, depression, boredom, nervousness and distrust.
- Perceptual barriers: education and training, intelligence, occupation, experience, competence and skills (Emmitt & Gorse, 2007), interests, social background and

personalities (including personal values, reputation/history, extroversion/introversion and the knowledge base) (Burke, 2007; Van Staden et al., 2002).

- The influence of the social and physical environment on relationships
- Organisational pressure, work pressure (Emmitt & Gorse, 2007)
- Semantic barriers: the meanings of the words used are misunderstood, or different meanings are attached to specific words or expressions (Tubbs & Moss, 2008).
- Environmental barriers that affect the sender and receiver, such as personality, physical appearance, leadership, timing and decision-making. (Gillard & Johansen, 2004)

To ensure successful collaboration, all partners need to interact with each other and use the resources and information as and when needed (Chinowsky, 2012). Thus, to achieve effective communication on site, potential problems need to be understood, and solutions identified. The main aspects of communication are: having a communicator, identifying the information to communicate, and determining the most effective methods to deliver information within the project environment. The obstacles also relate to aspects of communication, which include the complexity of the project environment as a multi organisational culture; this reflects the noise of the communication process, information issues related to the message itself, the technology and tools available to deliver the message, and the knowledge, skills and culture of the communicator/s. Figure 2-4 illustrates the range of communication problems

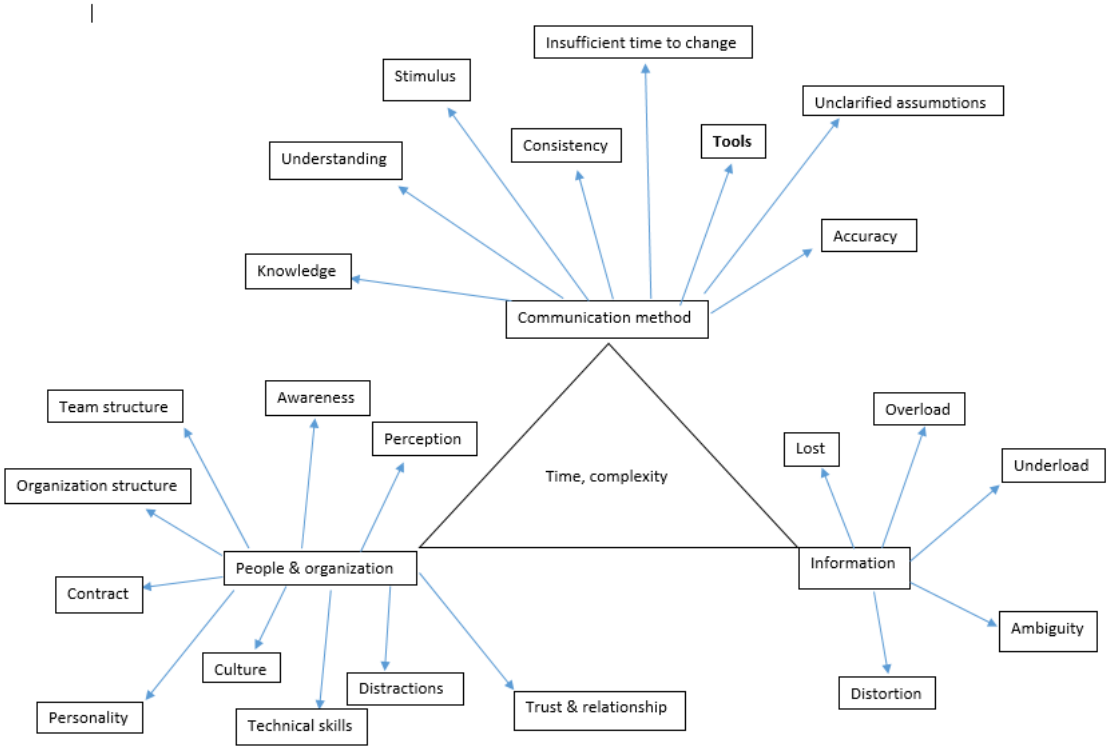


Figure 2-3 Site communication problems (Source: developed by the researcher)

2.8 Summary:

This chapter provided an understanding of the main causes of problems in communication and information exchange in construction. It outlines the communication and information flow techniques in construction. The chapter reviewed the process of communication in detail, including how it reflects on the delivery of messages. It also explored key communication concepts including communication media, whether it is verbal or nonverbal, and communication channels. Moreover, both informal and formal communication methods were reviewed. The chapter considered the complexity of construction, which has a multi-organisation culture, and different levels of communication were outlined. This chapter reviewed the literature on effective communication within construction projects, including the definition, need and use of effective communication in controlling the flow of project information. Further detail about the barriers and challenges and how they relate to the information types were examined alongside the people and organisations involved in communication, and the critical importance of understanding communication as a tool to achieve effective communication and information exchange in a complex environment, such as a construction site. Linking the aspects of communication helped to outline the challenges that need to be understood in more detail. The following chapter discusses the challenges and impact on communication in more detail.

3 Aspects of On-Site Management:

3.1 The Nature of the Industry

Egan (1998) argued that the construction industry is no different from other manufacturing sectors. He stated that many buildings are repeated products with repeating processes that make construction improvable. Moreover, precise specifications and contracts define construction processes (Egan, 1998). Nevertheless, there are informal processes within construction projects (Dainty et al., 2007), and managing an onsite project is generally considered to be one of the challenges of project management (Brandon, 2017). The Construction Industry Institute (CII) (Hopper, 1990) suggested that informal organisational behaviour processes are a parallel structure to formal structures; they exist to maintain lines of communication, coordination, problem-solving and decision-making when a structured process is not working properly (Dainty et al., 2006). Furthermore, Mayouf (2014) formulated the 'analogy of the 'organisational iceberg' in which the formal communication above the surface is underpinned and supported by a mass of informal communication 'below the sea level'. In addition, collaboration is understood to comprise 80% people and processes and 20% technology, which this stresses the importance of individuals. Thus, the industry must develop a collaborative culture with demonstrable behavioural competencies within organisations at all levels. Where this occurs, communication should be effective in creating value for an organisation, and tools should add efficiency to that effectiveness (Hillson, 2010).

3.1.1 A Complex Industry

The nature of communication in the construction industry is complex, due to the variety of organisations involved in the project process (Bouchlagem et al., 2004; Charoenngam et al., 2003). As a result, a range of reports is prepared to deliver information to all stakeholders and individuals. Moreover, Cheng et al. (2001) explained that different professions are involved from different organisations in construction projects, including architecture, structural engineering, quantity surveying, civil engineering, project management, and building surveying. These multidisciplinary skills build boundaries that scope cooperation; however, this potentially creates problems with communication. According to Love et al. (1998), inter-organisational coordination must be adopted through effective communication, information exchange, partnering and performance monitoring.

3.1.2 Highly Fragmented and Non-Collaborative

When construction teams only focus on conforming to contractual requirements, this reinforces the increasing division and fragmentation of the industry (Brandon et al., 2017; Latham & Egan, 1994). Moreover, Craig and Sommerville (2006) state that the construction industry is highly fragmented, non-collaborative and unique, whilst Cheng et al. (2001) argued that the industry needs to change its current culture to be more collaborative. Nevertheless, Latham (1994) and Egan (1998) suggest that an information sharing culture should be used among the project team to collaborate across organisational boundaries (Egbu, 2000). This fragmentation of the industry was also well demonstrated by Anumba and Evbuomwan (1998).

3.2 The Importance of People Skills

Construction is a people business, and as such, the relationships between employees are critical when aiming for project quality and efficiency (Walker, 2015). Effective communication results in better-shared understanding; this can lead to better collaboration between all parties which results in better quality projects. Individuals could achieve the greatest benefit from communication by developing a level of trust that encourages the sharing and exchange of information and ideas. Good relationships could be built faster and achieve more effective communication, thus increasing the likelihood of completing a successful project (Brandon et al, 2017; The National Archives, 2013).

The knowledge of how teams develop is important in understanding the significance of people skills at each stage. Many researchers identify how teams develop from a general organisational perspective, offering different models to explain this process. The model that has been developed by Tuckman (1965) is still the most appropriate for the construction context. According to Tuckman, there are four stages of team development during its lifespan, which are: forming (when the team comes to work together); storming (conflict and the competition within the team to rise to higher level); norming (team members try to set norms for appropriate behaviours); and performing (team maturing as an effective team). This process could help to build an effective construction team by involving the group in many tasks and activities.

However, construction is different from other industries (Ball, 2014); it is not homogeneous as every project has a unique character and nature that increases the complexity of construction projects (Emmitt & Gorse, 2009). In order to manage this complexity, skilled people are required. In construction, there are unique problems within each job and continually changing

plans that lead to complex daily decisions (Langford et al., 2014). Construction workers do not have the option to suggest different ways of performing their work; they simply have to perform it differently (Langford et al., 2014). Accordingly, it is important for team members to offer a highly skilled contribution that considers not only the technical skills, knowledge and experience but also their inter-personal qualities and ability to collaborate constructively with others in order to achieve a shared goal (Wheelan, 2014). This is particularly important as National Statistics (2013) highlighted that the construction industry has poor productivity levels and lags behind other industries. Thus, Emmitt and Grose (2003) stated that the way in which organisations and individuals interact during the project is fundamental to the success or failure of a construction project.

Hanafi et al. (2010) identify the adequacy of relevant information, communication problems between construction workers and supervisors, a lack of information, and communication breakdown as some of the most important factors that control labour productivity on-site. Similarly, Love et al. (2016) state that one of issues that leads to rework in the construction industry is human error, which may increase project costs and time. Table 3-1 details the conditions that contribute to human error. This highlights the importance of implementing effective communication to help to reduce some of the errors.

Observation	Comment
• No one had a clue; they had different understandings of the same event	Parties involved in a rework event all had differing opinions as to how and why it occurred, as demonstrated in the example presented in Table 1. Basically, what may be apparent to one individual will be different to another. People select information to make sense of a situation as they perceive it to occur. It is deemed to be easier for people to seek confirming evidence for their current understanding than to test it and risk having to invest in significant time and effort in devising another explanation
• People filter out most of the information around them	In this instance, people are only interested in the information required to undertake their task. If information is missing, then they may request it, although this will often depend on the level that is required. People possess a hierarchy of mental filters and thus select the information that best suits their needs
• Cultural differences increase the likelihood of different interpretations of the same event	Differing parties involved in a delivery of a project have differing goals and objectives, which are crafted as a result of their organization's culture. What is considered relevant to one person may not be relevant to another as a result of the task that they are undertaking; thus, sociopolitical and organizational pressures can shape their perceptions and memory of an event
• Problems arise when the goals of people in the same organization start to diverge	Organizations involved with delivering construction projects tend to have differing goals. A lack of understanding of each participating organization's roles and capabilities leads to divergence and problems arising
• People break rules to make work more efficient	Time and cost are innate features of construction projects. Thus, within this context people make trade-offs between efficiency and thoroughness, which is guided by the experience and training a person has been given
• People's decisions are a trade-off between the available information and the available time	People often do not have enough time to complete their tasks. As a result, they rely on an alternative approach to produce the best decisions using the available nformation within the time they have. In addition, within construction, there is a great deal of uncertainty and complete information is often not made available
• People make mistakes. Organizations make it possible for the mistakes to be really serious	Inadequate time, design, staffing, and the lack of good management that contribute to errors may also combine to make a situation even worse. For example, building failure may result in injury or even deaths

Table 3-1 Observations of the Conditions Contributing to Human Error (Love, et al., 2016)

Zulch (2014) explained that many factors affect the way that participants communicate; the project manager adopts the main role in building trust and effective leadership communication, which includes behaviour, personality, background and attitude. Figure 3-1 shows the relationship between effective communication and leadership:

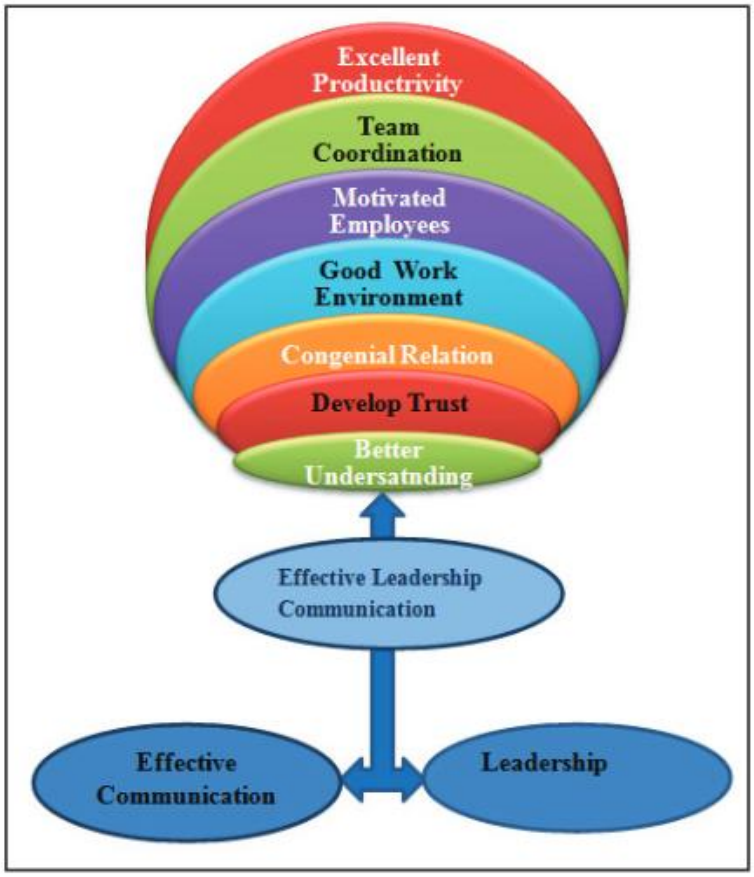


Figure 3-1 A Conceptual Model for Effective Leadership Communication (Source: Luthra & Dahiya, 2015)

Rather than suffer a lack of resources, systems or equipment, the reason why many projects fail to achieve an optimum level of performance is because they inadequately address human factors (Burke & Barron, 2014). The failure of a team to focus on the objectives of a project, relying instead on unclear goals or inspirations, could represent a key leadership weakness (Burke & Barron, 2014). Thus, considering people in an organisation is essential to achieve the project goal; however, the number of organisations and the diverse disciplines involved also increase the complexity of the project team. Managing a team under these circumstances requires skilled managers and committed team members.

3.2.1 Leadership and Managers' Skills

'… the better the project manager communicating, the smoother the project will go'

Heldman (2011:33)

Construction organisations require leaders who will respond to the changing nature of the industry in order to develop and achieve maximum effectiveness (Burke & Barron, 2014). Leadership is the skill of planning, directing, motivating and building trust among a team. The project management profession has subsequently started to implement many technically supported methods of planning and leading. Thus, while current project management systems have increased, better management skills are needed to manage the culture change and increase interpersonal communication (Dulaimi, 2005; Ingason & Jonasson, 2009; Ofori, 2008).

Leaders across all organisations are the people who: motivate, inspire and align people; communicate a vision of organisational goals; plan activities, tasks and budgets; map the direction to implement change; establish a team environment and team decision making; recognise the need for immediate action; coach and support subordinates; communicate with all shareholders; and encourage stakeholders to interact professionally (Steyn, 2012; Zenger et al., 2009). Moreover, a person will generally lead people in accordance with their personal characteristics and knowledge. Ekung et al. (2015) indicated the importance for project managers to improve their ability to communicate, organise, build teams and provide leadership (Ofori, 2008). The best project leaders are able to engage team members at a personal level and encourage, empower and inspire them to participate in a project (Burke & Barron, 2014). Moreover, they are able to manage conflict whenever disputes or crises arise (Sunindijo et al., 2007).

When the organisation is experiencing a threat or crisis, either by external or internal events, the need for effective communication increases; managers who need to address these kinds of situations should be highly skilled communicators (Burger et al., 2015). Furthermore, they are particularly important for their role in communicating in order to constitute, manage and maintain the relationship between stakeholders. A mixture of skills is essential to manage a project successfully, such as cognitive aptitude, interpersonal ability, technical competencies and the capability to understand people and situations through demonstrating appropriate behaviours (Pant et al., 2008). Many organisations today expect their employees to have many skills, such as group development and teamwork, in order to increase the productivity of the

project. Thus, Burke and Barron (2014) stated that, with their particular skills in working with people, managers have the greatest influence on project management practices.

Ofori (2008) stated there is a need for project managers to change the way they lead and work as the industry represents a considerable cultural, political and business environment. It is therefore important to select the right people to help realise the Key Performance Indicators, which are typically (Emmitt & Gorse, 2003):

- Client satisfaction (product and service),
- Predictability (cost, time and quality),
- Profitability,
- Productivity,
- Defects and conflict,
- Safety,
- Construction (cost and time).

3.2.1.1 Project Stakeholders and their Relationships

Stakeholders are those who are involved in the process of the project and have a role and impact (Steyn, 2012). Stakeholder needs and expectations are identified by the project teams with a view to managing and influencing expectations, and successfully completing a project. Any person or organisation that takes part in the project process is considered a stakeholder (Steyn, 2012).

The term ‘stakeholder’ is used to refer to any participant of a project, which includes: the project manager, the client (or the sponsor), the main contractor and sub-contractors whose employees are directly involved in doing the work at the project (Knipe et al., 2002). Furthermore, this comprises the external participants (who will be the end users), senior managers, other key experts, environmentalists, and the community.

The roles of participants involved in the project affect the project team’s communication and the relationships that exist among the team members (Higgin & Jessop, 1965; Udeaja & Tah, 2002). The relationships with other stakeholders are controlled by contracts; this also controls the critical information flows (Ekung et al., 2015). When a relationship is built on a contractual

basis, it is important to communicate the contractual documents among all the parties. Having a structure-based contractual relationship helps team members to improve their formal communication as it is supported by specific roles and specifications (Lofgren, 2009). Moreover, procurement methods state the methods that need to be used to communicate between the stakeholders (Xie, 2012). Projects in different procurement systems involve different parties within the contractual arrangement. However, the role of one participant could involve different responsibilities within different types of procurement systems (Egbu, 2004); thus, the first step to understand the communication among the project team is to identify the general contract type used in that project (Egbu, 2004). The forms of procurement usually adopted in construction are traditional (Design-Bid-Build), design and build, and management contracting.

It is argued that traditional procurement methods were unlikely to harbour collaborative relationships (Verster, 2006). In this method, three main parties are involved: the client, the designer and the main contractor. The client has a direct contractual relationship with the designer and main contractor (Shohet & Frydman, 2003). Furthermore, the contractual requirements limit the communication lines in a construction project (Pietroforte, 1999). Pietroforte stated that interactions amongst parties in a traditional method contract are reflected in their communication, which adopts an impersonal and bureaucratic character, as shown in Figure 3-2.

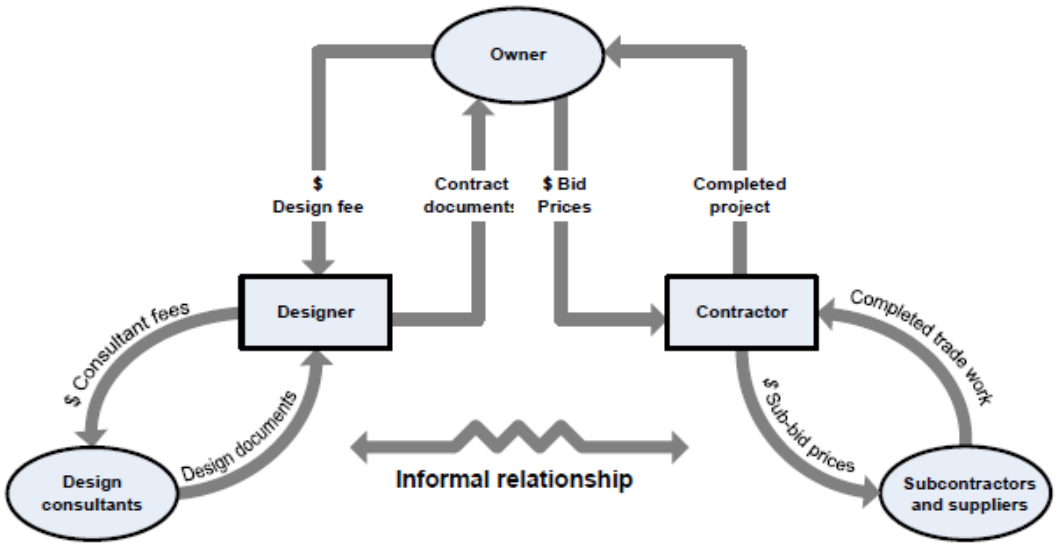


Figure 3-2 Traditional Methods (Source: Gould & Joyce, 2013)

In this method, the client agrees on a start date with the designer who will have formalised an agreement with the consultants. Meanwhile, the main contractor signs a contractual agreement

with the owner, which relates to the documents prepared by the architect. From this, the main contractor signs the contract with the subcontractors to undertake their part of the job. However, the subcontractors and suppliers only have a relationship with the main contractor (Pietrofote, 1999). At the construction stage, the main contractor's roles are to manage their subcontractors, control the construction work, and report to the client. The contractor checks the quality and schedule of the work undertaken by the subcontractor (Gould & Joyce, 2013).

Another procurement method that been mostly used in UK construction projects is design and build. In this method, the main participants in the agreement are the main contractor, who takes full responsibility for the design and construction stages, and the client, who undertakes an agreement with the main contractor. The main contractor holds the full responsibility for the project; they employ their own subcontractors to undertake the tasks. The main contractor reports to the client in terms of the progress, cost, quality and payment. Figure 3-3 shows the relationship between the parties.

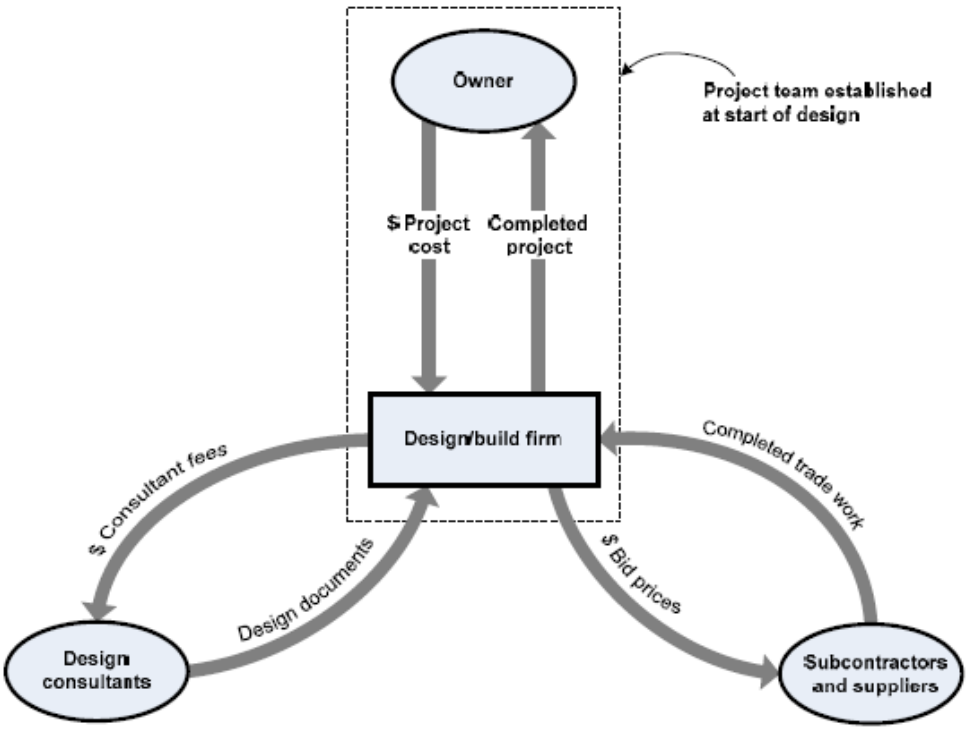


Figure 3-3 Design and Build Method (Source: Gould & Joyce, 2013)

The complexity of construction projects has led to the development of the last procurement method, namely construction management. In this method, there is no main contractor as the client builds relationships directly with the various specialist subcontractors. The client's

representative controls and manages the information flow during the project lifecycle. (Shohet & Frydman, 2003), as Figure 3-4 shows:

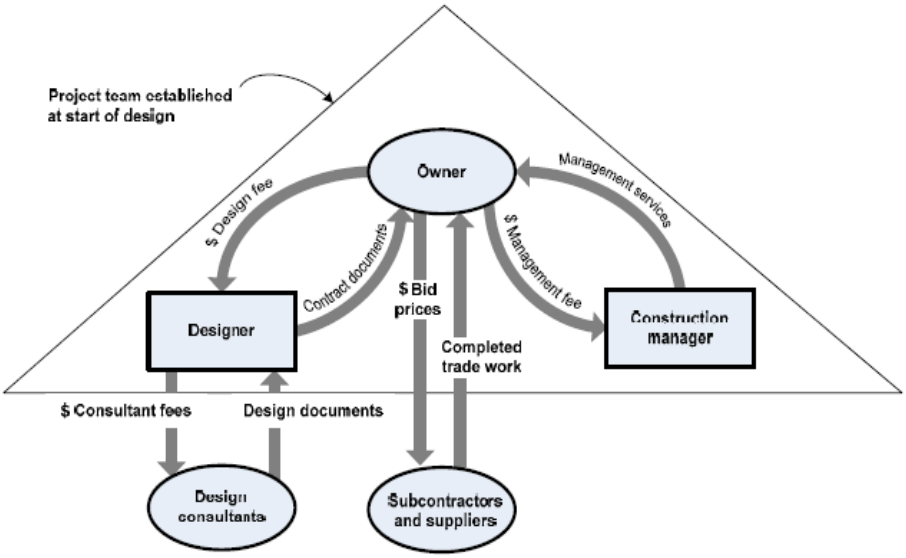


Figure 3-4 Construction Management Approach (Source: Gould & Joyce, 2013)

The contract documents form the basis of the communication methods with the client, subcontractor and other professionals. Shen (2009) confirmed that this contract is usually adopted in order to build a formal relationship with the project teams. It is understood that the contract guides the communication that relates to the rights, obligations of parties, and administration by all the parties involved.

Puth & Ewing, 1998 clarifies that the primary problem in the construction sector is communication management, and one of the reasons behind this is a lack of understanding of the substance of the process. According to Shohet and Frydman (2003), contracts define the timelines of communication as teamwork communication relies on the timely transmission of essential information. Thus, any delay to that information could cause a misunderstanding that leads to problems and conflicts. Before the project begins, communication lines need to be identified by selecting an appropriate procurement method. Contractual communication documents more than communication; it demands the sharing of a set of documents with other participants, including drawings, specifications, contracting requirements and other documents related to the agreement payments and the schedule. Although the contract documents establish minimal communication requirements, many conditions control the need for communication, including requests for changes, requests for information, changes to orders, submittals,

processes and reports, and payments. In this research, the procurement method that has been considered is design and build, where the focus is the main contractor.

3.2.1.2 Trust Development

Rousseau (1998) described trust as an individual belief and willingness to act on the basis of words, actions, and the decision of another. In comparison, Hertel et al. (2005) argued that trust is a psychological state comprising the intention to accept vulnerability based upon the positive expectations of the intentions or behaviour of another. However, improving communication and trust helps to improve the exchange of information, although confidential information should not be shared as its release could increase conflict (Wong et al., 2008). Furthermore, Heffernan (2015) stated that collaboration should be considered in parallel with competitive prices when defining the contractual relationship in the procurement process. A relationship built on a competitive bidding process can be antagonistic and generate mistrust and dispute (Wong et al., 2008), whilst, on the other hand, favourable tenders generate a collaborative environment among the project stakeholders (Wong et al., 2008). A connection that is based on companies can act as an alternative form of trust (Gulati, 1995), as the repeated deals and interactions between firms achieve better knowledge and help to develop confidence in decision-making. As such, trust incrementally increases as it correlates with the repetition of economic and social relationships. Nevertheless, verified certification, references and reputation are also an important source of trust (Jones et al., 1997).

A reputation can be used as a context from which organisations can acquire knowledge, behaviour, abilities and reliability (Jones et al., 1997). Also, this process may form a negative impact if deemed to have unfairly functioned in the past (Rooks et al., 2000). Once the relationship is determined, the experience of the stakeholders helps to gather information related to behaviour, performance and the ability to check reality against expectations (Heffernan, 2015). In construction, stakeholders have same goals; therefore, there is a need for trust to enhance collaboration, information sharing and problem-solving. Nevertheless, in complex and fragmented natural environments, trust could be risky and costly as individuals cannot compel collaboration. Parties need to communicate continuously to develop the trust that could help them to transfer information effectively.

3.3 Information and Communication Technology (ICT)

Information Technology (IT) is defined as he means used to transfer, store or manage information (Webster, 2014). This encompasses radio, television, cellular phones, computer and network hardware and software, satellite systems, and so on. Meanwhile, information and communication technology (ICT) is dedicated to storing information, communication and processing (Sin Tan et al., 2010). Shen et al. (2009) defined ICT as a collective reference for processing information and computing technology. This reflects the improvements to technology over time and demonstrates that it is still developing. According to Wikforss and Löfgren (2007), this development takes place on organisational and global levels. Nevertheless, ICT is a complex term that represents the following three concepts:

- *Information* has a various meanings to different people. Information, scientifically, is processed data. Information could aid decision-making; it could also be considered a useful and unique fact, value or quantity (Kembro & Näslund, 2014; Mohd Zin & Egbu, 2010)
- *Communication* means the transferral of information or exchange of data so its reaction is the result of another action. Communication could be defined as the transfer of ideas, information, thoughts or messages as a process (Emmitt & Gorse, 2009)
- *Technology* means the invention tools that use scientific knowledge in order to assist humans in their daily lives (Schröpfer et al. 2017). In this concept particular entities, such as radio, television, mobile phones and computers, denote technology.

In order to enable effective communication between different users, many tools have been provided. These support the exchange of information through a network, called virtual teams (Bouchlaghem, 2012). Online collaboration through Internet meeting systems can reduce the need for physical meetings, which leads to an important saving in both time and resource and a significant improvement in the sharing of information. When the organisation has the ability to adopt new ways of working, new technology can support effective communication. However, the best technology will not inherently enhance the ability of collaborative work and information sharing nor improve the productivity of individual or team; therefore, the key to achieving the greatest benefits is to encourage behavioural change and to learn how to adapt to a new environment (El-Saboni, 2009).

3.3.1 ICT in Construction

Harris and McCaffery (2013) argued that ICT is a method to manage and exchange information by focusing on the information processes within the construction industry. The use, exchange and maintenance of information can address information flow management during the project process. An organisation utilises ICT in order to create and manage knowledge, facilitate inter- and intra-organisational collaboration and exchange information (Schröpfer et al., 2017). Ekholm and Molnar (2009) state that with well-defined information structures and efficient communication, ICT can be an effective tool for product development, production, the supply of materials, and maintenance in the manufacturing industry (Tah, 2001). ICT as collaboration tools are usually adopted to support a high level of interaction, information sharing, and group communication (many to many) for known users in different geographical boundaries, times and divisions (Andriessen, 2012).

Moreover, Cheng et al. (2001) mentioned that many behavioural and cultural aspects of the work environment could be affected by the introduction of ICT into engineering organisations. Thus, in order to encourage a smooth transition to a new system, there needs to be a consideration of cultural difference; this enables the management of the change and helps to avoid the 'individual fair' of technological change. In implementing an effective organisational system change, it is necessary to consider the end user before endorsing any action that requires business change (Finne, 2003). Nevertheless, focusing on the implementation of the information system does not lead to good collaboration and it has been proved to be less than successful (Hosseini et al., 2013). In contrast, focusing on cultural and organisational issues will not bring greater benefits from the use of ICT, particularly in construction where a distributed team is essential. Thus, the implementation of ICT could result in the effective management of collaboration within the organisation (Sin Tan et al., 2010)

Over decades, many researchers have identified that poor information management, a lack of information sharing among stakeholders and issues with ICT utilisation are the main cause of problems in the construction sector. However, ICT can play a key role in helping the construction industry to successfully meet its goals (Hosseini et al., 2013). The widespread adoption of ICT in construction could lead to shared common business processes, improved communication between participants in a construction project and the reduction of problems generated by fragmentation. Egbu (2004), El-Saboni et al., (2009). Martínez-Rojas et al. (2015), Ma. (2015), Viljamaa & Peltomaa (2014), and Sardroud (2015) stated that, although

construction is an industry that has adopted ICT in order to improve data exchange and the communication and collaboration among the parties involved in projects, its adoption is still slower than for other industries. The main reasons for this are:

- The structure of the industry, which is highly fragmented,
- Projects tend to be unique and complex,
- Challenges associated with organisational cultures,
- The temporary nature of construction projects,
- The inadequate coordination and inefficient means of communication of project information and data,
- A lack of knowledge and skills in the use of ICT,
- A lack of document and data standardisation, and
- An unclear return on investment in the short-term.

3.3.2 Information Sharing

Information sharing is the main ingredient for any organisation to stay competitive (Dantas & Seville, 2006). According to Ruikar et al. (2005) ensuring that information is up to date and available to access within the organisation can result in a boost to profitability. Similarly, Premus & Sanders (2008) and Kembro & Näslund (2014) noted that information sharing can result in many benefits. Some of these benefits increase the value through enhanced planning and decision-making processes, improved relationships within the organisational environment, and reduced inventory levels.

The needs and behaviours concerning information sharing have to be controlled by the organisation's culture; sharing information within and between organisations aims to support decision-making in emergency situations, to improve the visualisation of data, and to consider the possible benefits of better sharing (Arif et al. 2011). In order to increase the organisation's performance, information needs to be distributed continually within organisations (Kembro & Näslund, 2014). Sharing information among organisations and members mostly leads to increased organisational productivity and reduces the product development cycle time (Barua et al., 2007). In the construction industry, losing data through information exchange, and the rework and dedication of time to investigate useful information in a document could lead to inefficiencies, including wasted time and costs (Nor & Egbu, 2010). This is because

information is required from multiple stakeholders for multiple purposes. Emmitt and Grose (2009) believe that there are seven important characteristics to consider in order to ensure effective information.

- Clarity and brevity: although it is easy to understand the importance of this characteristic it is difficult to achieve. This is because of the difficulty in presenting information in text or drawing, and its reception depends on the receiver's knowledge and needs. Delivering the amount and type of information required to undertake the job is necessary to avoid overload. Thus, items or tasks should describe one facet using one type of document. (Belton, 2002)

- Accuracy: confusion will result in waste, error or delays on site. Using an appropriate language to communicate instructions will help to ensure the meaning is delivered accurately.

- Consistency: throughout the life of the project, the same words, symbols, graphics and dimensions should be used consistently. Having IT packages to deal with information could help in this regard.

- Avoiding repetition: repeating the same information in many documents wastes resources (time, cost) and could lead to confusion, error or avoidance by the receiver.

- Redundancy: this is always included in the contact information. Coordination and careful editing from sources should help to reduce redundant material.

- Checking: before being issued, information should be double checked by everyone who participates in the production of the information, and are specifically involved fixed standards, codes, consultants, and recommendations. In the process of preparing information, checks are often left to individuals, which means that it is subject to error. Conversely, when multiple checks are required, most parties sign the checking sheet as the other person has checked it already and thus they do not follow the checking procedures (Issa et al., 2008).

- Timeliness: receiving information at the right time increases the quality and value of the information. Ensuring an appropriate amount of time to deliver and issue information should be carefully considered.

3.3.3 IT Applications

New technological methods of communication have emerged, such as email, the Internet, multimedia, and virtual reality. New technologies are changing both the way of exchanging information and communication activities; they play an essential role in improving construction sector communication (Anumba & Evbuomwan, 1997; Rojas & Songer, 1999; Shen, 1992). The development of IT use in construction started in the 1980s, when computers

began to be used for documentation issues, whilst the early 1980s saw the emergence of personal computers, and construction programming began to be established for design and scheduling. Computers thus developed as a communication medium to improve supply chain relationships. In 2003, Shohet and Frydman (2003) suggested that the use of email could increase collaboration and improve communication among project teams in the construction industry. They mentioned that Internet-based communication processes would be important to increase the effectiveness of communication, and to thus create a virtual communication network environment (Austin et al., 1997).

In 2002, Dawood et al. (2002) noted the development of an automated communication system that could function as a site document management system; this facilitated information and data exchange among project team members. Furthermore, Caldas and Soibelman (2005) suggested that providing a computer-aided collaborative environment could improve communication and ease the information exchange in construction sites. Abduh and Skibniewski (2004) reviewed academic research work to develop a web-based collaboration system for information exchange and project management. They mentioned that application service providers have developed and offered many web-based project management systems that were used within the construction industry.

Thus, the rapid global development of technology and the Internet has produced different technological innovations that create, transfer and store information in many disciplines (Wainwright & Oliver, 2010). Electronic Document Management Systems (EDMS) are shared points to manage huge amounts of information, including drawings and documents, and specifications created during the project lifecycle that use metadata (Ruikar et al., 2005). NISO (2004) states that metadata is structured information that can describe, explain, and locate, which means it is easier to manage an information resource. It is important to understand the difference between a document as content and the information about that document as metadata, which enables the search for and retrieval of documents from a database (Derks & Bakker, 2010). They also stated that the key function of a successful project is the efficient exchange of information. Document Management Systems (DMS) provide structured documents that can be used as evidence to settle disputes.

Nowadays, the storage of computer files has widely replaced the use of paper in construction. However, many construction projects still use paper alongside digital documents. These

technologies are considered more cost-efficient compared with the traditional means of communication, and create savings within communication among parties (Deng et al., 2000). Electronic Document Management Systems (EDMS) provide consistency within document generation, including the exchange of documents, ease of access and ease of use of information management. In addition, the use of EDMS has improved the quality of documentation and enabled more structured information (Sommerville & Craig, 2006). Since the construction industry is still using email as a tool to exchange information, the potential for EDMS has not yet been fully realised (Jernigan, 2008). Jernigan stated that managers are still using non-integrated tools to communicate and the management of documentation has not undergone a corresponding change. In construction, the nature of projects is complex, involving multidisciplinary participants, multiple phases of a project lifecycle and various information system tools; thus, the need for effective communication is vital (Phelps, 2012).

Nevertheless, technology could represent a huge impediment to the development and maintenance of interpersonal relationships, and could precipitate conflict. Technology for communication has become more common in both work and life, and become a standard feature for many stakeholders (Bergiel et al., 2008; Hertel et al., 2005). It has developed rapidly, dissolving many time and distance barriers; thus, the construction industry now demands the use of virtual communication (Dewar, 2006), which offers many advantages, for example organisations can adopt virtual communication systems. Nevertheless, face-to-face communication, either individually or in a meeting, has some advantages, and many studies state that it is impossible to replace it, regardless of its evolution (Duke, 2001). Indeed, face-to-face methods allow the communicator to read the receiver's reaction and their body language in order to gain rapid, relatively accurate feedback and to adjust any shared information (Powell et al., 2004). It can also help members to learn about one another's background, skills and knowledge as well as to build trust within a group that communicates face-to-face and reduces the time to make decisions. If communicators are based in different locations, a face-to-face approach is more complicated; nevertheless, many participants still prefer this method of communication (Powell et al., 2004; Rosen et al., 2007).

Although social presence, namely the interpersonal dimension, can improve team effectiveness (Lin et al., 2008) Dewar (2006) states that setting ground rules for effective communication could reflect in more predictable and timely responses between members and enable greater levels of trust within a team. Lin et al. (2008) suggested that setting dates and times for regular

meetings and having a phone and email accessible for the individual avoids the reliance on email as the sole means of communication. Thus, the organisation should use other database options to exchange information (Hertel et al., 2005; Powell et al., 2004). Finally, Lin et al. (2008) considered that effective communication could be achieved when teams engaged in regular dialogue, although the effectiveness of the team was still ambiguous.

3.3.3.1 Communication tools and methods on site:

Verbal and nonverbal communication usually takes place in construction; despite the development of new technologies, traditional methods of communication still exist and are needed on site (Emmitt & Gorse, 2006). These forms of communication are detailed as follows;

- Formal meetings: this usually includes an agenda and a list of required attendees. Mostly it is repeatable at a specific time during the construction process. Meeting minutes are typically taken and these are shared with the attendees and other involved parties within a few days of the meeting. Meetings at the construction stage could include; preconstruction meetings, internal progress meetings, main and subcontractor progress meetings, and client progress meetings.
- Informal meeting: this is an unscheduled meeting that could be called to address an issue or to make a decision. It is used more than a formal meeting as it could be easily held between individuals, such as a conversation during a site visit. It is more effective for immediate discussions and can enable a quick solution to an issue. This type of meeting needs to be documented and followed up in the form of written communication to clarify any misunderstanding that could arise.
- Design review: this is a meeting to discuss and agree project-specific issues. Again, it needs to be recorded and the record distributed to the parties involved.
- Client presentations: this type of meeting updates the client with progress, costs and the quality of the project up to the meeting date. The environment of these meetings depends mostly on the size and type of project.
- Telephone conversations; these are a quick and cheap way to solve problems or report on minor queries or issues. They could fill the gap between written and face-to-face communication, and are useful when parties are located in two different locations. However, they should be documented when important decisions are made or instructions given.

- Written instructions: these are widely used on a construction site as part of the day-to-day activities. They are used to confirm prior oral methods and provide evidence in the event of a dispute.
- Reports: these are used to provide or request information, or request approval or decisions. Reports could be attached with photographs, drawings, programmes and spreadsheets. They could be required for situations, such as design reports, progress reports, technical reports, inspection or defect reports. The misreading of reports can occur although it is important to keep reports clear as feedback could be limited (McLeod, 1996).
- Letters are important to confirm an action or to point to a particular issue. They are considered a type of short report. These can be less formal than a report.

Furthermore, as previously mentioned, the development and increase in technology has resulted in the adoption of new methods to communicate, which include:

- Emails: this is an unstructured text environment that is used to transfer documents, (usually as attachments, storage, and archives, and to manage documents (Liew, 2013). Emails are a limited system; information should be abbreviated and summarised to a level that facilities its transmission. The potential for error through the use of email is high. However, it is widely used as a communication method to exchange information between parties. Even though it is limited in richness and the amount of information it can convey, many people still prefer to use it (Ballan & El-Diraby, 2011). Phelps (2012) stated that the majority of information shared amongst project participants by email is not valuable to the overall project. In construction, the incorrect perception of email usage could be due to the lack of research on the concept of email in this field; instead, it has just been adopted as a tool to share and communicate information in order to reduce the time in transfer (Deng et al., 2000).

3.4 Mobility in Construction

The concept of mobility is when people have to move in order to perform their work (Wikforss, 2007). There is an increase in the mobility of both the design and production phases of projects. By relating to the place of work, designing mobile would offer project workers greater possibilities in the field than those available in their offices. In construction, mobility is important when considering the environments where people work; in such spaces mobility is crucial.

In addition, there is a greater application of sensing technology to construction sites in order to generate automated data, such as Global Positioning System (GPS), Ultra-Wide Band (UWB), digital photogrammetry, and laser scans which support as-built drawings (Turkan et al., 2012). Moreover, Radio Frequency Identification (RFID) supports the tracking of material to improve on-site processes (Ju, 2011), whilst Building Information Modelling (BIM), which is defined as a set of interacting policies, processes and technologies, represents an opportunity to manage the project throughout the lifecycle (Mayouf, 2014). Thus, improving the use of technology in construction industry helps to ease the exchange of data, and consequently, enables effective communication.

3.4.1 Radio Frequency Identification (RFID)

Radio Frequency Identification was invented to improve the ability of construction businesses to track tools and materials, to check activities on site, to improve the supply chain and to help promote improved health and safety (Schneider, 2004). RFID enables the reading or writing of information by scanning tags that are attached to tools or materials and used in the construction sector. This can be achieved with low-cost scanners, and eventually result in the 'track and trace' of individual items or, in some cases, individual employees (Ju et al., 2011). RFID can improve the quality of data within organisations by replacing manual data collection methods with automated ones. Moreover, it can help make information about assets or resources more visible (Sørensen et al., 2010). The RFID provides an easy means to establish information, such as the location of an item is, what it is and the last time it was used; thus, it can connect items and their locations as well as the people who use them. Overall, RFID offers new prospects to improve new products and services in the construction industry (Asif, 2005). This technology has subsequently underlined areas of potential cash saving and efficiency improvements through increasing productivity, collecting data, tracing quality and control, managing stock, and developing customer information.

3.4.1.1 The Advantages of using RFID in Construction

RFID is a proven technology for monitoring materials and tools, capital assets and people. It provides information about the usage and tracking of consumable goods. The areas of RIFD application within the construction industry include: controlling the location of valuable properties; maintenance, control and management; controlling sites or areas within the sites as well as monitoring security staff activities on site; plant hire; identifying and tracing materials;

creating financial benefit; tracking the materials from the manufacturers to sites including the final construction site; reducing the loss of materials, tools and capital items to enhance security; speeding information flows on the location of equipment, tools and materials; improving the inventory control on materials and tools; reducing the waste of time and materials; increasing the control of health and safety and maintenance processes; improving tracking progresses in order to ease decision-making; reducing paperwork increasing efficiency in construction, and providing proof of delivery as an aid to on-site quality (Ergen & Akinci, 2007; Wang et al., 2007; Zare, 2011). These advantages translate into financial benefits.

However, the use of RFID technology is still limited in the UK (Vijayaraman, 2006) due to:

- Technical problems: such as issues with RFID Standards, the easy disruption of systems, RFID Reader Collision, and RFID Tag Collision.
- Security, privacy and ethics problems: such as the inability to remove RFID tags, that RFID tags can easily be readable by other devices, and tags can be scanned from a greater distance with a high-gain antenna.

3.4.2 BIM

Nowadays, the construction industry is undergoing huge changes due to improvements within Building Information Modelling (BIM), although it carries the possibility of conflict in challenging traditional ways of working (Eastman et al., 2011). BIM is a new technology involving a set of processes that handle structured data, which helps to visualise and develop intelligent objects and 3D spatial models of buildings and infrastructure assets. BIM should be implemented as a single database and consist of fully integrated and interoperable information that can be used seamlessly and concurrently by all project professionals throughout the project lifecycle (Gu & London, 2010). It enables organisations to better connect and work on construction projects. In computer science, the term BIM covers an enormous range of concepts and there is no common definition for the entire sector; thus, based on differing organisational experiences and positions, a number of definitions have emerged. BIM is the main information repository with embedded intelligent objects and metadata with a number, name and meaning for each element characteristic (Eastman et al., 2011). The application of BIM increases the accessibility of information, which reflects on improvements to communication. Indeed, Succar (2009) refers to BIM as vital for communication.

According to McGraw-Hill (2009), in 2009, the adoption of BIM among the UK construction professionals surveyed was 35%. The BIM process depends on the right set and tools to build a shared information resource that represents a 3D model accompanied by a full project database, and to present a consistent source for decision-making throughout the project life-cycle (buildingSMART, 2010; McGraw-Hill, 2009). Underwood and Isikdag (2010) consider that BIM is an important technology for supporting interoperability, knowledge capture and communication during the project lifecycle. Therefore, BIM is important for communicating information, which has been underlined in many governmental reports (BIM task group, 2013).

Moreover, BS1192 (2007) stated that the collaboration between organisations is essential in order to ensure the efficient delivery of projects. This suggests that more organisations working collaboratively helps to accomplish higher quality standards and enable the better re-use of knowledge and experience. The BRE (2015) and BIM Task Group (2013) have published reports explaining that BIM can improve communication and productivity. On the other hand, they have argued that, if a BIM strategy is aligned with another related process, such as Lean, this would result in the clear development of construction performance. The construction sector did not initially fully understand the substantial benefit of third generation collaborative technology (DiVanna, 2003), nor that organisational structures are affected by these technologies and change employees' roles and responsibilities. However, the Group Support System (GSS) is the root of technologies that support BIM, which enable the parties within a project to communicate and share information in order to resolve problems and make decisions. This is important, as decision-making and problem solving are important tasks to discuss the different points that require more interaction and information sharing. Nevertheless, GSS groups might not be able to perform as a face-to-face group due to their need for rich communication media.

BIM is a shared point of information; its advantages have been identified as important in both theory and practice (Arayici, 2009; Ballesty, 2007; BSI, 2010; Eastman et al., 2008). These advantages include: improved effective communication; a consistent approach to data procurement; information management; the assurances and validation of quality; the integrity and the completeness of information; reduced time and costs; shared structured information; intelligent and flexible documentation; improved information security and governance; fewer Requests For Information (RFI) and order changes; clarity in the construction sequence; improved energy analysis and simulation; a better vision and simulation of design to encourage

stakeholder engagement; multidisciplinary coordination; improvements to facilities management, and providing a common data environment.

The barriers and challenges to the uptake of BIM have been underlined by researchers, and these include (Arayici, 2010; Gu & London, 2010): A lack of knowledge; a lack of training; the dispersed nature of the construction industry; resistance to change the industry culture; unwillingness to adapt and accept new technologies; a lack of clarity on roles and responsibilities; a lack of understanding Lean processes; a lack of highly developed technology (hardware and networking resources); a lack of integration and interoperability; the hardware and software costs and the overall cost of BIM adoption, and ownership of the model/liability and insurance issues. Due to these barriers, the use of BIM in UK construction is still limited.

3.5 Literature Summary

The literature review chapters reviewed the importance of communication as key to the successful delivery of a construction project. This analysed the process of communication between the sender and receiver, including the difficulty, importance and barriers that could influence its effectiveness. Understanding how communication takes place and the delivery method are essential for the success of a project. The key considerations in delivering effective communication are 'who, where, when, how, which or what' in relation to the message. This entails:

- Understanding the journey of the message and how sender's and receiver's knowledge could change its meaning.
- Knowing the type of information needed to undertake any project and whether the information is issued to start the project or requested during its construction; this means having the right information at right time and delivered to the right operatives.
- Understanding the organisational structure and the relationship between team members.
- Understanding the importance of managers on a construction site.
- Understanding the importance of participants' communication skills to build trust and the promotion of a shared environment in order to enable effective communication.
- Understanding the increased use of technology in other industries and a focus on both the technology and process of project information.
- Understanding the complexity of construction projects.
- Noting some of communication barriers and difficulties.

Therefore, the main difficulties that impact on the effectiveness of communication in the construction industry are: People and their organisations, the information that needs to be communicated accurately, and the techniques that need to be used to deliver that information (whether technological or traditional), as shown in Figure (3-5).

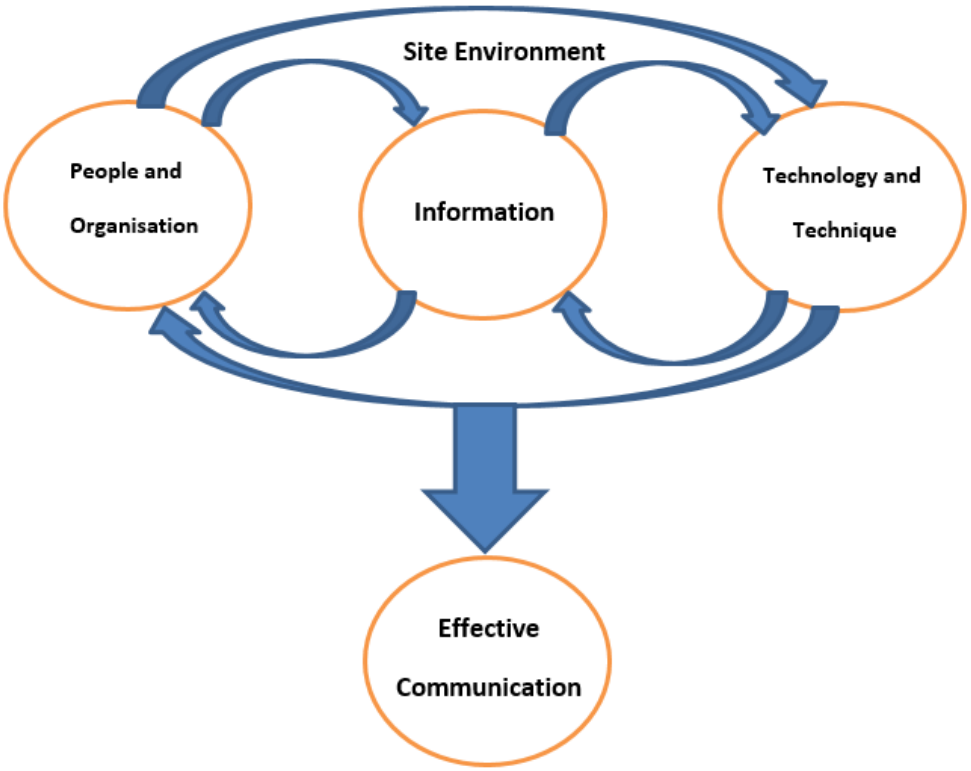


Figure 3-5 Effective Communication Aspects (Source: researcher's illustration)

4 Research Methodology

4.1 Introduction:

"What one decides to study has methodological consequences."

(Holstein & Gubrium, 1995)

This chapter explains and justifies the research methodology used. It also distinguishes between research methods and methodology. The choice of methodology entails a larger view or understanding; for example, it is a choice of road or direction that takes a researcher from place A to B. Each choice has advantages, disadvantages and implications, and relates to particular methods or techniques; for example, getting to place B by car, train or busand the implications for each option. Although it might appear that many methods can lead the researcher to place B, usually only one method is optimal. Easterby-Smith et al. (2012) and Marshall and Rossman (2006) defined research methodology as the combination of techniques used to investigate a specific situation, and the individual techniques include the data analysis and collection methods, and so on. Research is a systematic investigation to increase the sum of knowledge in order to provide a better understanding of a phenomenon and/or change a social circumstance (Fellows & Liu, 2009). In order to study a phenomenon, researchers are expected to employ suitable methodologies, which define how a study is conducted. Furthermore, specific research techniques (i.e. methods) that fit the methodology and phenomenon under investigation should be used (Silverman, 2013).

It is vital to achieve the aims of the research; the term refers to the overall approach of the research process, from the theoretical underpinning to the data collection and analysis (Bryman, 2012). The reasons for selecting the particular methodology for this research will be outlined. In order to do so, it is important to discuss the research philosophy, approaches, and strategy, as well as to outline some of the data analysis methods concerning management and construction research. Furthermore, the chapter will explain why other research methods are deemed unsuitable, and therefore eliminated.

4.2 Research Philosophy:

Traditionally, in most research and books on research methodology, the philosophical underpinning of the research is usually the first element discussed (e.g. Bryman, 2012; Creswell, 2009; Creswell & Clark, 2007; Easterby-Smith et al., 2015; Saunders et al., 2011). It

is argued that setting out the philosophical position has multiple advantages in terms of clarifying, optimising, and enhancing the quality of the research design (Creswell & Clark, 2007; Easterby-Smith et al., 2015). However, the process that most researchers follow in practice is to start with a research problem that triggers the research process, without necessarily clarifying a philosophical state. The effects of the philosophical underpinning are usually implicated in the way researchers perceive, shape, and answer research questions (Saunders et al., 2011). Although researchers often question the practical benefits of philosophical thinking, a researcher's attitude implies a certain philosophical view. For example, a researcher who believes that explicitly stating a philosophical position is impractical and the research question is the determinant factor of a certain philosophy tends to follow a pragmatist's philosophy (Saunders et al., 2011).

> *"…. we believe, perhaps less naively than the reader might think at first, that any method that works –that will produce clear, verifiable, credible meaning from a set of qualitative data- is grist for our mill, regardless of its antecedents."* (Miles & Huberman, 1994, p.3)

Thus, most management research stresses that philosophical positions are not a 'shopping list' to choose from; inquiries do not usually fit neatly within a certain philosophy (Saunders et al., 2011). People's views and assumptions of philosophy represent the nature of knowledge (Saunder et al, 2009); thus, the way a researcher perceives the world informs the assumptions that they subconsciously make about the nature of the inquiry and the creation of new knowledge. According to Easterby-Smith et al. (2015), a research philosophy includes epistemology, which is concerned with the nature of knowledge, ontology, which is concerned the nature of reality, and axiology, which concerns the researcher's values and opinions (Saunder et al, 2009). More precisely, Terre Blanche and Durrheim (1999) defined ontology, epistemology, and methodology as three dimensions of the research process. Maxwell (2005) adds paradigms, which concern the influence or role of social actors and users. There are two main views or paradigms, namely positivism and phenomenology (Collis & Hussey, 2003). Logical positivism generates hypotheses, which consider that accepted knowledge is only knowledge based on an experience or sense of the world. This philosophy uses quantitative and experimental methods to test hypothetical-deductive generalisations. In contrast, phenomenological inquiry uses qualitative and naturalistic approaches to understand human experience inductively and holistically in context-specific settings (Amaratunga et al., 2002). The positivist approach seeks the facts or causes of phenomena, with little regard to the

subjective state of individuals, whereas a phenomenological approach is concerned with understanding human behaviour.

Nevertheless, the two major schools of thought on research methodology are epistemology and ontology (Bryman, 2012; Henn et al., 2006; Saunders et al., 2012), and they are located in the outer layer of the diagram shown in Figure 4-1. This illustrates that the outer layer (the research philosophy) is a shell shielding the entire research process.

Figure 4-1 The relationship between the research philosophy and methods (Source: Adapted from Saunders *et al.*, 2012)

Most research related to methodology tends to use certain analogies to explain the researcher's approach, and subconsciously considered philosophies (Easterby-Smith et al., 2015; Saunders et al., 2011). Many terms describe ontological and epistemological positions; however, the following sections are based on Easterby-Smith et al. (2015), Saunders et al. (2011), Creswell (2009) and Bryman (2012), who are key authors in management and business research.

4.2.1 Ontology

Ontology is concerned with the nature of reality; it examines the assumptions and claims that the research makes in relation to the knowledge that exists, and with a focus on the form in which the knowledge exists. This also considers how it can be presented, the different parts that comprise knowledge, and how those parts interact (Saunders et al., 2012). Moreover, some researchers have stated that ontology is concerned with understanding social entities in the social research context (Creswell, 2013; Ritchie & Lowis, 2003). Different ontological positions have been identified by Easterby-Smith et al. (2015) which include; realism, internal

realism, relativism, and nominalism (Table 4-1). Meanwhile, Ritchie and Lowis (2003) identified three major positions, which are realism, materialism, and idealism.

Ontology	Realism	Internal Realism	Relativism	Nominalism
Truth	Single truth	Truth exists, but it is obscure	There are many 'truths'	There is no truth
Facts	Facts exist and can be revealed	Facts are concrete, but cannot be accessed directly.	Facts depend on viewpoints of observer	Facts are all human creations

Table 4-1 Ontological Views (Source: Easterby-Smith et al., 2015)

Realism dominates research in the natural sciences; realism assumes that only one truth exists and the world is an external reality that depends on people's views and beliefs. On the other hand, relativism is the belief that there are many truths. Meanwhile, nominalism is the belief that there is no reality, and all realities are created by human actions (Easterby-Smith et al., 2012). The debate is therefore based on the appropriateness of internal realism, relativism, and nominalism to social research. Other authors classified ontological positions into two theoretical positions, which are objectivism and constructivism (Bryman, 2012; Grix, 2002; Saunders et al., 2012; Walliman, 2006).

Objectivism is the belief that the existence of social phenomena and their meanings are not dependent on social actors as facts that have an independent existence. In comparison, constructionism is the belief that the constant state of change of social phenomena is totally reliant on the social interactions in which they take place (Bryman, 2012). Cicimil et al. (2006) stated that the body of knowledge on project management emphasises the role of project actors and managers as 'implementers', which narrows their role to issues of control (time and cost) and content (planned scope of work). Thus, projects can be seen as socially constructed. In a complex project, the wider potential role of individuals as competent social and political actors is marginalised (Geraldi et al., 2008; Maylor et al., 2011).

Objectivism typically assumes rationality, universality, objectivity, value-free decision-making, and the possibility of information exchange and communication. This reduces conflict on site among the project team. This normative view promotes the field as practiced, and can be summarised as the application of knowledge, behaviours, responsiveness, skills, tools, and techniques to project activities meet project requirements (Cicimil et al., 2006; Flyvberg,

2001). Easterby-Smith et al. (2015) explained that objectivism can be found in certain social phenomena, independent from the researcher, and beyond their influence or reach, such as culture and generation. This indicates an internal realist ontology. Objectivism allows for research to be undertaken through standardised procedures. In this respect, organisations have a hierarchy and mission statement; they have a reality that is external to individuals, but at the same time, experts pressure to conform (Bryman, 2012).

Interactions between stakeholders result in a constant state of change, in both relativism and nominalism. Agreed behaviours are the social product of communication between parties (Bryman, 2012). Thus, constructionism does not negate the reality of objectivism; however, it stresses the active role of individuals' communication (the processes) in the construction of a social reality. Therefore, various people experience a phenomenon differently in diverse times and places; this denotes relativism (Easterby-Smith et al., 2015). Constructionism is also concerned with the meanings (knowledge) people attach to experiences, in creating social reality. In this sense, there is no truth and instead, "the interesting question is how people attempt to establish different versions of truth", which is nominalism (Easterby-Smith et al., 2015). Therefore, both relativism and nominalism accord with the aim, objectives, and questions of this research.

4.2.2 Epistemology

Epistemology is the nature of knowledge with a special focus on the process used in gaining the knowledge of the physical and social world. It addresses what should be regarded as acceptable knowledge (Bryman, 2012; Saunders et al., 2011). Thus, epistemology aims to investigate the kind of knowledge produced, how the knowledge was developed and the conditions applied to differentiate valid knowledge from invalid knowledge (Easterby-Smith et al., 2015; Walliman, 2006). It is worth stating that every study must identify and take a specific epistemological position throughout the research process. According to Walliman (2006), epistemology can be divided into two main parts: objectivism or named positivism. This entails the belief that social reality can only be known and understood via the application of natural science methods (Walliman, 2006). Social constructionism, or interpretivism, is the belief that, in order to understand social reality, there is need to study the actors involved in the process. This implies that social realities are created actors who reveal interpretation and meaning (Bryman, 2008; Saunders et al., 2012). Therefore, it is clear that adopting a particular

epistemological position will influence the methodology used in the investigation (Easterby-Smith et al., 2015) (Table 4-2).

	Positivism	Social Constructionism
The observer	Must be independent	Is part of what is being observed
Human interests	Should be irrelevant	Are the main drivers of science
Explanations	Must demonstrate causality	Aim to increase general understanding of the situation
Research progresses through	Hypothesis and deduction	Gathering rich data from which ideas are induced
Concepts	Need to be defined so that they can be measured	Should incorporate stakeholders' perspectives
Units of analysis	Should be reduced to simplest terms	May include the complexity of 'whole' situation
Generalisation through …	Statistical probability	Theoretical abstraction
Sampling requires …	Large numbers selected randomly	Small numbers of cases chosen for specific reasons

Table 4-2 The implications of positivism and social constructionism (Source: Easterby-Smith et al., 2015)

Social constructionism corresponds to relativism and nominalism in accepting that many aspects of social reality are determined by people rather than by objective factors (Easterby-Smith et al., 2015). As such, the researcher's job is not only to understand the frequency of difficulties and communication, but also to acknowledge the different meanings that people place on their experience. How people communicate, how they think both individually and collectively, and what motivates them, are questions that produce the knowledge of such research. Therefore, social constructionists need to talk to people to find answers.

Furthermore, Easterby-Smith et al. (2015) stated that interpretivism focuses on the belief that researchers need to understand how humans act differently as social actors. Humans as actors play roles in accordance with their interpretations (theirs or their organisation) (Saunders et al., 2011). However, humans do not only interpret their own roles, but also the roles of others (for example, a sub-contractor). This can result in a re-adjustment of their own interpretation

regarding their roles. It is useful to highlight that the phenomenological tradition refers to how humans act to make sense of the world, which is reflected as interpretivism.

In this research, the main concern is communication and the exchange of information in construction projects, which is considerably complex (Bertelsen, 2003; Dainty et al., 2006). Neither communication nor complexity have universally accepted definitions as they both are multifaceted concepts. This suggests that an approach to capture tacit knowledge and informal relationships would be useful.

The researcher adopts an interpretivist_epistemological view, or in other words, social constructionism. This is because humans set out the strategy to communicate and exchange information; thus, humans interpret, use, and update it. Individuals have their own interpretation. In the case of site construction offices, the contractor (client/subcontractors) controls a set of information and communication methods. From this, the main contractor (the leader of the project) sets their own methods and techniques to control the overall communication on site to exchange information with the parties involved (the subcontractors). It is important to understand how parties perceive the information and how they, individually and collectively, make sense and interpret the meaning by using the most appropriate method.

Every research study has its own ontological and epistemological positions or assumptions. Grix (2004) asserted that ontology and epistemology are the fundamentals of every study as they play a major role in deciding the research methodology and methods. However, many have failed to understand the relationship that exists between these key terms, which can muddle the research process. This is clearly discussed here to prevent the author from making similar mistakes. For instance, it has been observed that ontology is usually confused with epistemology while methodology is usually confused with methods (Blaxter, 2010; Bryman, 2008). The consequence of these confusions is the omission of the logical sequence that exists between each concept. Figure 4-2 shows the relationship between each concept and the logical sequence.

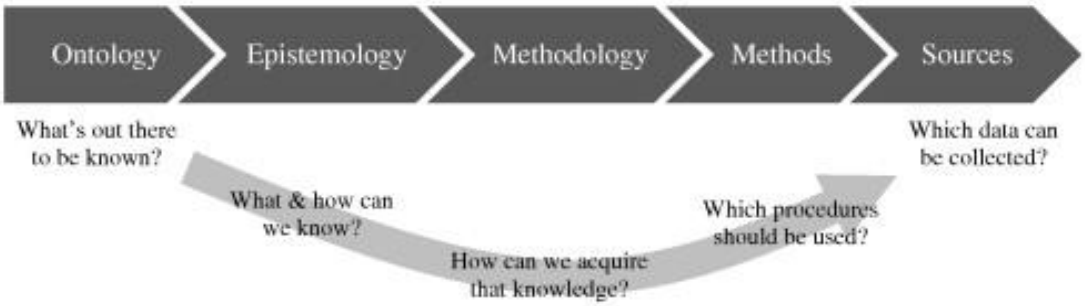


Figure 4-2 The relationships between ontology, epistemology, methodology, methods (Source: Grix, 2004).

The implication of this interrelationship is that research cannot just commence at any point in the diagram. This further emphasises the need to allow an ontological and epistemological position to shape the research process. Easterby-Smith et al. (2015) stated that ontological positions and their corresponding epistemology have a different effect on the selection of methodology (Table 4-3).

	Realism	Internal Realism	Relativism	Nominalism
Methodology	Strong Positivism	Positivism	Constructionism	Strong Constructionism
Aims	Discovery	Exposure	Convergence	Invention
Starting points	Hypotheses	Propositions	Questions	Critiques
Designs	Experiments	Large surveys: multi-cases	Cases and surveys	Engagement and reflectivity
Data types	Numbers and facts	Mainly numbers, with some words	Mainly words with some numbers	Discourse and experiences
Analysis	Verification/ Falsification	Correlation and regression	Triangulation and comparison	Sense-making; understanding
Outcomes	Confirmation of theories	Theory-testing and generation	Theory generation	New insights and actions

Table 4-3 Methodological implications of different epistemological views (Source: Easterby-Smith et al., 2015)

Research methodology plays a key role in the generation of knowledge in projects and their management (Smyth & Morris, 2007). Research into management focuses on the meaning of

peoples' actions. The interacting elements in organisations are people; thus, it is essential to explore their behaviour, which gives rise to emergent properties. Understanding the difference between philosophies and the ways in which knowledge constructed is essential for the research process

4.3 Research Approaches:

Authors have used various expressions to define research approaches; irrespective of the notion. These research approaches use a variety of research methods and techniques for the data collection (Thomas, 2004). Research methodology texts, in general, cite two main approaches - inductive and deductive (Creswell, 2009; Miles & Huberman, 1994; Saunders et al., 2011). Furthermore, Thomas, (2004) argued that there is a third approach for consideration, namely the abductive approach, which refers usually to mixed methods. The three approaches can either be used independently or all together in research. Each approach is explained in the following sections.

4.3.1 Deductive Approach

The deductive approach indicates that theory guides the data collection and analysis strategy, which are designed to test the hypotheses. Thus, the deductive approach is concerned with testing theory (Ketokivi & Mantere, 2010). The researcher usually starts by identifying a theory through a literature review, which results in a hypothesis and embedded concepts. This hypothesis is then operationalised in relation to the concepts and tested empirically using the data collected. Saunders et al. (2012) state that deductive reasoning specifies that the conclusions are drawn rationally from a set of assumptions, which would be true if all the assumptions were true. This is the most common view of the relationship between theory and research, which corresponds with positivism. The approach dominates research in the natural sciences.

The deductive approach follows a positivist philosophy, and works from the more general to the more specific; it is informally called the 'top-down' approach, as it starts with a general theory and narrows to a specific hypothesis, which is tested (Saunders et al., 2012). Therefore, this approach requires a highly structured methodology to deliver repetition and guarantee reliability (Gill & Johnson, 2010; Saunders et al., 2012). According to Bryman (2012) and Saunders et al. (2012) the deductive approach is associated with a quantitative research design.

IT helps to operationalise concepts and captures facts quantitatively while dealing with simple elements to enable a better understanding of the concepts.

4.3.2 Inductive Approach:

The inductive approach means that the data collected are explored and analysed using the literature to develop or generate a theory in the form of a conceptual framework (Bryman, 2012; Saunders et al., 2011). The inductive approach is associated with an anti-positivist philosophy. Moreover, it is important to understand that the use of the word 'theory' could be misleading as not all inductive research concludes with a concrete theory, but rather with more insightful generalisations, and interesting, illuminating findings. This approach specifies that the conclusion is judged and verified through observations of the real world. (Eisenhardt & Graebner, 2007; Saunders et al., 2007). The inductive approach is mainly associated with a qualitative research design (Bryman, 2007; Saunders et al., 2012). In contrast to quantitative research, in an inductive approach, the researcher has the ability to explore different views of a certain phenomenon. Hence, there is no need for a large research sample (Easterby-Smith et al., 2008; Saunders et al., 2012).

There is no clear-cut approach to follow in the practice of research; therefore, inductive research will inevitably involve a deductive approach and vice versa. It is argued that even the most inductive researchers are bound by their background knowledge, which is selective in the way they observe and interpret the world (Miles & Huberman, 1994; Walliman, 2005). Moreover, an iterative process is followed by some research where theoretical reflection is conducted on the data, and further data are collected to establish the conditions in which the theory holds or not (Bryman, 2012). Most social research starts with some key concepts that help orient the research into further steps; this is known as deduction. These concepts are later developed, and new concepts emerge as a result of the data collection and analysis, this is considered induction. (Bryman, 2012; Saunders et al., 2012). Thus, the researcher believes that the research approaches are located on a continuum with pure inductive and pure deductive at the two extremes.

4.3.3 Abductive Approach:

The term abductive was coined by Peirce (1957) to contrast with deductive and inductive reasoning. The approach is broadly inductive but distinguished by its reliance on explanations and its understanding of participants' worldviews. As Peirce explained, abductive research relies on intuition in grasping the whole meaning of something rather than following a

conscious logical process. This approach moves back and forth between theory and data. Therefore, it provides a level of flexibility for researchers to collect and analyse their data (Bryman, 2012; Thomas, 2004). The aim of an abductive approach is to investigate a phenomenon to generate or amend a theory by discovering themes and explaining patterns in the data collected (Ketokivi & Mantere, 2010; Saunders et al., 2012). According to Peirce (1957), the abductive approach is not a conscious logical process, but rather an intuitive leap that comes forth as a whole; "It is this intuitive grasping of the whole meaning of something without a conscious logical thought process that is the essential nature of aesthetic experience." Taylor (2004) notes the felt meaning that individuals may apply to information as they try to make sense of events. Although some individuals may reflect on the felt meaning and question it over time, there is a propensity to trust the naturally grasped felt meaning because it is based on feelings, i.e. it just feels right. The abductive approach seems to move back and forth between the inductive and deductive approach to integrate these approaches and draw conclusions (Saunders et al., 2012). Therefore, researchers are able to lead their research procedures according to data analysis to adopt their methodological choices and to explore new issues. Table 4-4 summarises the three approaches.

	Deduction	Induction	Abduction
Logic	In a deductive inference, when the premises are true, the conclusion must also be true	In an inductive inference, known premises are used to generate untested conclusions	In an abductive inference, known premises are used to generate testable conclusions
Generalisability	Generalising from the general to the specific	Generalising from the specific to the general	Generalising from the interactions between the specific and the general
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth
Theory	Theory falsification or verification	Theory generation and building	Theory generation or modification;

			incorporating existing theory where appropriate, to build new theory or modify existing theory

Table 4-4 Deduction, induction, and abduction: From reason to research (Source: Saunders et al., 2012)

The choice of research approach tends to follow an inductive approach. However, the data collection started with an initial set of concepts (a basic framework). As the study focuses on understanding human behaviour from the participant's point of view, this is contrary to the positivistic approach that tends to explain behaviour from the researcher's perspective (Bryman, 2012; Neville, 2007).

The goal of this study is to understand how the current understanding and application of technology enables the exchange of information and effective communication in the UK. This is based on a complexity perspective that aligns with the advocated processes of communication. Having critically examined the various research approaches in the preceding sections, it is not germane for this study to take its own philosophical stance to achieve its ultimate goal. The importance of taking a philosophical stance and its role in shaping the research process has been emphasised by numerous authors (Dainty, 2008; Fellow and Liu, 2009; Grix, 2002; Henn, 2006; Saunders et al., 2012). Johnson and Duberly (2000) suggested that researchers should take philosophical stances that match their profile and nature of the research, and potentially help to understand and address the concerns of the study. As discussed in previous sections, the most utilised approach in social science research, and by extension construction management, is a mixture of inductive and deductive. These are outlined including the justification for their use in this study.

Furthermore, a deductive approach is more aligned with the methodologies that enable a researcher to develop an understanding of problem when there is limited knowledge on the subject under investigation. It also allows the views, positions, concerns and meaning ascribed to the problem by the participants to be known and not limited to that obtained from the literature (Cole, 2006; Fellow and Liu, 2008). All these align with the aim of the study. However, the study also seeks to objectively identify the impact of technological communication methods on the exchange of information process by considering the impact of complexity on site offices. It also intends to objectively evaluate and validate the technology developed to support construction stakeholders, which requires a positivist stance. Based on this understanding, the chosen approach in this study is a mixture of inductive and deductive

(Henn et al., 2006; Saunders et al., 2012), as it enables the researcher to achieve the study's aim and objectives.

The effective combination of inductive and deductive in conducting construction management research has been widely reported in the literature (Dainty, 2008; Fellow & Liu, 2008). Dainty (2008) asserted that inductive/positivist (quantitative) and deductive/interpretivist (qualitative) research have their roots in ontology and epistemology, and thus can be combined. Accordingly, the approach of this research is abductive, with a closer tendency to the inductive.

4.4 Research Strategy:

The research strategy is defined as, "the way in which research objectives can be questioned" (Saunders et al., 2009). The researcher should be able to answer the particular research question/s and meet the objectives of the project, maximise the researcher's time and contribute to existing knowledge and resources. The choice between qualitative and quantitative research forms the research strategy (Bryman, 2012).

4.4.1 Quantitative Research:

Quantitative research is an inquiry into an identified problem, based on the testing of a theory. It is measured by numbers, and analysed using statistical techniques. According to Fellow and Liu (2008), quantitative approaches tend to relate to positivism; they seek to gather factual data and to study relationships in accordance with the theories and findings of previously executed research (Bryman, 2012; Dainty, 2008). Scientific techniques are used to obtain measurements, namely quantitative data. Analysis of these data yields quantified results and conclusions, which are derived from the evaluation of the results in light of the theory and literature. Miles and Huberman (1994) assert that a researcher taking a quantitative approach might draw a large and representative sample from the population of interest, measure the behaviour and characteristics of that sample, and attempt to construct generalisations regarding the population as a whole. Basically, a sample survey and experiment are the methods used in the quantitative strategy.

4.4.2 Qualitative Research:

Fellows et al. (2008) define qualitative research as, "a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that makes the world visible". Qualitative research involves the use of qualitative data, such as interviews, conversations with participants, field notes, documents and participant observation data, to understand and explain

social phenomena (Myers, 2013; Silverman, 2005). Qualitative approaches are commonly used to describe phenomena about which little is known in order to capture meaning (in the form of individuals' thoughts, feelings and behaviours) rather than numbers and to describe processes rather than outcomes (Mayan, 2001). Since qualitative research is an iterative approach, research design should never be considered final, which means that the researcher should be flexible in changing the design as the research progresses (Myers, 2013). Flexibility is not bound to the pilot study phase, but the researcher should also be ready to make iterative changes in the data analysis stage.

To elaborate on qualitative research, (Silverman, 2006) explained that, "qualitative research is often based on interpretivism or constructivism". Thus, it is concerned with exploring subjectively how people use language to interpret the world within a cultural and lingual context. Creswell (2009) described the constructionist researcher as often addressing the "process" of interaction among individuals; the interpretivist researcher interprets data by developing a description of an individual, and finally, the inductivist researcher generates meaning from data collected in the field.

O'Leary (2004) states that the main methods to collect qualitative data are interviews, focus groups, observation and case studies. In some cases, triangulation (employing more than one method) is implemented. Table 4-5 presents a comparison of quantitative and qualitative research.

	Quantitative	Qualitative
General framework	-Seeks to confirm hypotheses about phenomena - Instruments use more rigid style of eliciting and categorizing responses to questions - Uses highly structured methods such as questionnaires, surveys, and structured observation	-Seeks to explore phenomena - Instruments use more flexible, iterative style of eliciting and categorizing responses to questions - Uses semi-structured methods such as in-depth interviews, focus groups, and participant observation
Analytical objective	- Quantifies variation - Predicts casual relationships - Describes the characteristics of a population	- Describes variation - Describes and explains relationships - Describes individual experiences - Describes group norms

Question format	Closed-ended	Open-ended
Data format	Numerical (obtained by assigning numerical values to response)	Textual (obtained from audiotapes, videotapes and field notes)
Flexibility in the study design	- Study design is stable from the beginning to end - Participant responses do not influence or determine how and which questions researchers ask next - Study design is subject to statistical assumptions and conditions	- Some aspects of the study are flexible (for example, the addition, exclusion or wording of particular interviews questions) - Participant responses affect how and which questions researchers ask next - Study design is iterative, that is, data collection and research questions are adjusted according to what is learned

Table 4-5 Comparison of Quantitative and Qualitative Research (Source: Yin, 2010)

The nature of this research and the aims, objectives and questions do not lend themselves to a quantitative approach. The research is of an exploratory nature and closer to an inductive approach, where the nature of that area investigated is firmly engrained in human behaviour, which is more interpretive. The data collected are words and descriptions of processes. Therefore, based on the above sections, and Table 4-5, this research follows a qualitative strategy that corresponds to both ontological and epistemological positions, and an inductive-abductive approach.

4.5 Research Design:

4.5.1 Research Purposes:

Fellow and Liu (2008) suggested that, in order to determine the most appropriate research choices, it is necessary to consider the logic that exists between the data collection and analysis from using the method. Research is viewed as a systematic and methodical process of inquiry and an investigation that increases knowledge and/or solves a particular problem (Kothari, 2004). The processes adopted to achieve the purpose of the research include reviewing and synthesising current literature on the related field of research, developing a new concept to describe the area and subject of research, and validating and presenting the findings in a form of new knowledge (Venable, 2006). The different approaches adopted n answering research questions are referred to as research strategies. These include, but are not limited to, the survey, case study, action research, ethnography and experiment (Rowley, 2002; Saunders et al., 2003).

4.5.2 Experiment:

This strategy has been widely used in social science, natural science, and particularly psychology. The experiment is used to study the causal relationship between two variables and to establish how the change in one variable will affect another dependent variable (Saunders et al., 2009). However, Blaxter (2010) points to the difficulty in choosing the 'control' variable in order to exclude all 'confounding variables'. Black (1999) states that experimental research is 'ideal'. However, he adds that, when it comes to human activity in real situations, experiments may either be impossible or introduce problems 'intrinsic to their configuration'. Quasi-experiments are introduced in situations that hold the same principles and logic, but are not as 'rigorous' (Black, 1999; Yin, 1994). Shipman (1997) also states that quasi-experiments have all the characteristics of experiments except they are dependent on self-selection or administrative decisions to determine who takes part. Bryman and Bell (2003) state that the use of "the experiment strategy in qualitative research is rare in business and management research due to the difficulty of achieving the requisite level of control required in organizations". An experimental strategy was not used as this research is exploratory in nature, which is reinforced by the research questions. Furthermore, there is no control over participants' activities in the settings, and the research questions confirmed that the researcher does not control events, but instead seeks information on how to exchange information in construction site projects.

4.5.3 Ethnography

Ethnography is a qualitative inductive approach that comes from anthropology. It brings the researcher closer to where the context of the research, reveals the worldview of people, and explains their daily cultural meanings (Myers, 2013; Saunders et al., 2009). Ethnography enables the researcher to interact with a group, "in a natural setting over a prolonged period of time by collecting, primarily, observational data" (Creswell, 2009, p.16). One of the crucial aspects of collecting data in ethnography is to witness participants' behaviours by participating in their activities (Creswell, 2009).

Henn et al. (2006) suggested that the use of an informal approach in conducting the investigation enables the researcher to observe and gain an understanding of the problem without being viewed by the participant as surveillance. In this approach, the goal of the researcher is to study participants in the setting to understand the problem without causing any form of obstruction to the activities undertaken by the participants.

Therefore, ethnography could have potentially been used in exploring how the current understanding and application of technology in delivering construction information from the main contractor's perspective in UK construction aligns with effective communication principles on site. This is due to its opportunities to interact and observe specific practice in a given context (Fellow & Liu, 2008; Saunders et al., 2012). However, there are criticisms of ethnographic research; for example, it is time-consuming because it occurs over a long period of time in order to enable the researcher to become immersed in the social world under investigation. For ethnography to be conducted appropriately, the following points need to be considered (Saunders et al., 2009):

- The researcher should select the group or setting for study carefully and ensure that such a group or setting will be able to answer research questions before immersing completely with them.
- The researcher should build a rapport and trust with the group for maximum cooperation.

However, the length of time required makes the strategy less suitable for this study, which has a limited time frame. Again, the focus of the study is not only to observe participants but to also understand the meaning the participants ascribe to the problem under investigation

4.5.4 Action Research:

This is a methodology in which the researcher engages with the phenomenon and actively observes a situation to bring about change. Action research consists of an iterative cycle of three steps: planning action, taking action, and evaluating the action, which leads to the repetition of the whole cycle, and so on. In action research, the researcher is constantly involved in the process of observing, identifying, and evaluating with organisational members in the researched case (Saunders et al., 2009). Heath (2004) stated that, for action research, it is important to move towards reflecting upon the role of pre-understanding only as theories begin to emerge, rather than in advance of the research

Action research relies on existing knowledge, including that from literature, practice, and the iteration of processes, in order to develop an innovative and systematic approach to address the identified problem (Hevner et al., 2004). The researcher must be actively involved in identifying, developing, and implementing the solution for the identified problem. The approach reduces the gap that exists between practice and theory in research (Koskela, 2008).

Given the proactive and practical nature of action research, in addition to the recommendation for its use in Lean construction (Koskela, 2008), this could be a potential approach in the conduct of this study, which focuses on the application of communication technology in the exchange information.

However, the focus of action research is to develop and implement a practical system in an iterative process to address the problem with the active involvement of the researcher. This study only created and piloted an approach to support mobile implementation from a communicational view towards the end of the study. Furthermore, the study is not claiming to generalise its findings, but seeking to explore different approaches

4.5.5 Grounded Theory:

The grounded theory method helps in the collection and analysis of qualitative data through the use of flexible sets of inductive strategies (Bryant, 2010). Marshall and Rossman (2006) clarify that the similarity between grounded theory and other qualitative methods is the focus on participants' perspectives and the reliance on people's words regarding their everyday experiences.

Whilst quantitative data may be more useful for a large sample, a grounded theory method could be aimed at studies collecting individual (qualitative) perceptions (Strauss & Corbin, 1997). This theory uses interactive and comparative methods to construct the analysis. Grounded theory allows for the exploration of new ideas by analysing data in a new way (Charmaz, 2014). Therefore, the method enables the direction and management of the data collection to construct original analysis.

Many diverse methods exist for data collection, such as transcripts of meetings, interviews, court proceedings, field observations, questionnaire answers, and other documents, such as letters and diaries. Indeed, some methods are better than others within the grounded theory as they better enable the collection of fresh raw data in contrast with manipulated data. Thus, this helps to build rather than just test a new theory (Denscombe, 2010). Nonetheless, because the sole purpose of the study is not to build a theory in data through an iterative approach, a grounded theory strategy is not applicable.

4.5.6 Survey:

The survey method is used to obtain a response from a large sample of respondents in a structured format. It is usually based on statistical analysis and uses a deductive approach

(Henn et al., 2006; Saunders et al., 2012). The knowledge acquired from the process could be generalised since the approach could be used to reach a larger number of respondents. It is notable that the respondents must be a true representation of the population of the study before such conclusions can be valid.

The limitation with this approach is that it does not allow for new perspectives or phenomenon on the subject to be gained from respondents. This is because the factors investigated are already predetermined by the researcher, which limits the views of the respondents (Henn et al., 2006). Surveys are more often used in management and business research. Consequently, the survey strategy is often linked with the deductive approach, such as questionnaires, structured interviews and structured observations (Saunders et al., 2009). In general, it is used in descriptive research with the deductive approach and tends to answer 'what, who, where, how much' and many other questions (Saunders et al., 2009). Surveys are used to provide a view of a section of a population at a particular point in time with the intent of generalising the findings. Longitudinal measurements may also be performed at several different times (Marshall & Rossman, 2006). Surveys are the most commonly used strategies in social science research (McQueen & Knussen, 2002), and attempt to discover facets of a society by studying small samples. Considering the exploratory nature of the study, starting the study with a set of predetermined questions, such as in a questionnaire survey, would not provide a perfect support to the aim of the study. This is because it would limit the participants' sharing of experiences on the problem under investigation.

4.5.7 Case Study:

The case study research is described as "an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p. 23). In comparison, Robson (2002), defines a case study as, "a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real-life context using multiple sources of evidence". In other words, the subject of the research is an example of a real-life event, within the context in which it happens. During a case study strategy, a researcher has the ability to answer the questions of 'why what and how'; thus, a case study approach is most likely used in explanatory and exploratory research (Saunders et al., 2009). Both the qualitative and quantitative data are used in a case study strategy, although, qualitative data are dominant (Robson, 2002).

Yin (2014) suggested three conditions that should inform the choice of the case study method; (1) when the study seeks to answer research questions such as 'how' or 'why'; (2) when the goal of the study is not to have full control over the phenomenon being investigated, and (3) when the goal of the study is to focus on real-life situations in a given context. All these align with the research questions this study answered:

- How does the current understanding and application of technology for exchanging information in site offices align with communication concepts?
- How can construction site teams be supported for the rapid use of technology, and mobile technology, in particular?

Yin (2014) observed that the case study approach is appropriate when a study seeks to know the 'how' or 'why' of an event. For instance, the goal of this study is to understand how technology, as currently practiced in the UK construction industry, aligns with effective communication and how construction organisations support the rapid and successful implementation of mobile technology. Also, a case study approach could investigate a single case or multiple cases; this is usually determined by the overall aim of the study or how the case study has been designed. The key advantage of adopting multiple case studies is that it allows the researcher to gain a better understanding of little-known problems or phenomena in a particular context using data from various sources; this is known as 'triangulation' (Leedy & Ormrod, 2001; Yin, 2014).

The techniques used in collecting data include, but are not limited to, unstructured interviews, observations, and documentary explorations. As shown in Table 4-6, each technique has its weaknesses and strengths (Yin, 2014).

Source of Evidence	Strengths	Weaknesses
Documentation	- Stable: can be reviewed repeatedly - Unobtrusive: not created as a result of the case study - Exact: contains exact names, references, and details of events - Broad coverage: long span of time, many events and many settings	- Retrievability: can be difficult to find - Biased selectivity: collection is incomplete - Reporting bias: reflects (unknown), bias of author - Access: may be deliberately withheld

Archival records	- Same as those for documentation - Precise and usually quantitative	- Same as those for documentation - Accessibility due to privacy reasons
Interviews	- Target: focuses on the case study - Insightful: provides perceived causal inferences and explanation	- Bias due to articulated questions - Response bias - Inaccuracy due to bias - Reflexivity: interviewee gives what interviewer wants to hear
Direct and participants' observation	- Reality –covers event in real time - Contextual cover - Insightful regarding interpersonal behaviour	- Time consuming - Selectivity: broad coverage difficult - Reflexivity: event may proceed differently because it is being observed - Bias due to participant-observer manipulation of event
Physical artefacts	- Insightful regarding cultural features - Insightful regarding technical operations	- Selectivity - Availability

Table 4-6 Strengths and Weaknesses of Sources of Evidence in Case Study (Source: Yin, 2014)

A case study strategy entails the collection of information by the researcher over a sustained period of time; furthermore, a case study is bounded by activity, time and the researcher (Creswell, 2009). Yin (2014) argued that the issue of lack of rigour can be overcome when different techniques are used in data collection; hence this is adopted in this study.

A case study design is an appropriate strategy for this research. Furthermore, multiple methods were used to collect the data. The case study method has been used to understand and address real-life situations in social sciences, business, information systems, and construction management, among others. The main potential of this method is to enable the researcher to develop a contextual understanding of the problem.

4.6 The Research Purpose:

"Each study starts questioning a phenomenon by asking 'what is happening?' and then seeks to understand 'how this is happening?'"

(Miles & Huberman, 1994)

The research design process involves planning how a research project will be conducted. This process specifies: the purpose of the research (i.e. the research topics and questions), the selection of the techniques used for the data collection (i.e. the methods and how to implement them), the choice of research site, population and sample for study, and how to collect the data, conduct the analysis, and present the findings (Gibson & Brown, 2009).

The starting point in any research design is an articulation of the research purpose or aim (Saunders et al., 2011). Depending on the nature of the research question(s), three classifications of research purpose exist, which, in turn, could be classified as descriptive, exploratory, and explanatory. Furthermore, pertaining to these classifications, Robson (2011) emphasises that the selection of method(s) is based on the kind of information sought, the source and the particular circumstances, although supplementary method(s) can be added during the project.

4.6.1 Exploratory:

An exploratory study explores phenomena when very little is known about the area under study (Voss et al., 2002). It helps to discover what is happening, and, "to seek new insights, to ask questions and to assess the phenomena in a new light" (Robson, 2002). Two types of exploratory study were distinguished by Yin (2009); the first is to 'find out' what, whereas the second is to determine 'how much'. An exploratory research is flexible in that it can change its direction and purpose as the researcher explores new data and obtains new insights. The researcher used a literature review to initially conduct this exploratory study.

4.6.2 Descriptive:

A descriptive study describes a phenomenon. It is more structured than an exploratory study, and focuses on fact-finding and on a few dimensions of a 'well-defined entity', measuring them systematically and precisely (Saunders et al., 2011; Voss et al., 2002). It asks the widest range of questions, namely 'who, where, what, how many' (Yin, 2009) and aims to portray an accurate profile of people, events, or situations (Robson, 2002). However, it should always be a means to an end rather than an end itself (Saunders et al., 2011). There are three ways of exploring, describing and accessing new data, and they are: reviewing the literature, interviewing experts, and conducting focus group interviews (Saunders et al., 2011). While Denscombe (2014) considered that surveys are well suited to descriptive studies, they can also

be used to explore aspects of a situation or to seek explanations and provide data to test hypotheses.

4.6.3 Explanatory:

The explanatory study examines and formally tests the relationships among variables. It is used to test relationships and seek answers to problems and hypotheses. However, the difference with an explanatory study is the scope of the description. Descriptive research seeks information about isolated variables whilst an explanatory study seeks the relationship between the variables (Saunders et al., 2011; Voss et al., 2002). The explanatory study asks 'how' and 'why' questions (Robson, 2002). However, the researcher believes that answering 'how' and 'why' questions depend on the philosophical view of the research. If the research is influenced by positivism and deduction, an explanatory study will seek to establish causal relationships. Alternatively, if the research is influenced by induction and qualitative concerns, an explanatory study will seek an explanation via interpretation. As Yin (2010) stated, explaining how or why events occur, or how or why people are able to pursue particular courses of action, requires an interpretive framework with an explanatory mode.

The previous descriptive study was not an end in itself but a precursory contribution to a subsequent explanatory study. In such a case, Saunders et al. (2011) calls the research 'descriptor-explanatory'. The research questions for this study emerged from applying the communication concepts to the descriptive study, and from this emerged a deeper understanding of how effective communication is influenced by the method and people that have been selected to exchange information on site. With the set of research questions, case studies were selected as a source of primary data, which are collected via two different (mixed) methods; observation and unstructured interviews. They were conducted in two site offices in the UK. The explanatory study had also a validation dimension.

The use of a mixed approach in construction management research has been widely reported in the literature (Dainty, 2008; Fellow & Liu, 2008). Bryman (2012) and Greene (1989) stated that the purpose of a mixed approach could be for: triangulation, facilitation, sequential research development, credibility, to compliment, gain fresh perspectives, and enable expansion (i.e. adding breadth to scope, enhancement, etc). The essence of a mixed approach in this explanatory study includes, but is not limited to, triangulation which validates the data and ensures that the communication process that supports the exchange of information is holistic.

4.7 Data Collection Methods

There are two important concepts behind the data collection. The first is the data sources and second is the method for generating results from those sources (Mason, 1996). The data gathered for an interpretivist research paradigm is a communication procedure between the researcher and participants (Fellows & Liu, 2003) The key factor of the data collection technique is the nature of the request and the data required in a certain setting or context (Naoum, 2013). Therefore, different techniques might be appropriate for different methods and inquiries. This research identified people as data sources due to their knowledge and experience. However, there are many approaches to generate data from these people, such as interviews, questionnaires, and observations (Saunders et al., 2009). As discussed earlier, the design of this research is a case study, which implies a method that could enable the collection of understandings, opinions, interpretations and ideas from people who have been involved in communication on site. Mason (1996) suggested four techniques for data gathering in interpretivist research, namely: interview, observation, the use of documents, and the use of visual data.

The epistemological position of this research suggests that the logical way to generate data is by interacting with experienced people. This research seeks to generate data from people's experiences in their current or past organisations, including how they interpret the relationship between information, technology, and effective communication, and how it can improve the level and quality of information exchange in the development of effective communication. The most common methods in qualitative research are interviews, participant observations, focus groups, survey questionnaires and case studies (Fellows et al, 2008). Yin (2009) states that no single source of data has a complete advantage over others, while the combination of multiple sources of evidence can help to clarify the real meaning of the phenomena.

4.7.1 Literature Review:

A literature and document review is critical in providing the basis of an inquiry, especially in developing the initial conceptual framework. A literature review plays a vital role in a research process, and has been defined as;

> "*… the selection of available documents on the topic, which contains information, ideas, data and evidence written from a particular standpoint to fulfil certain aims or express certain views on the nature of the topic and how it is to be investigated, and the effective evaluation of these documents in relation to the research being proposed*" (Hart, 1998, p.13).

Bryman (2012) observed that the essence of conducting a literature review is to understand what has been done in the area, the theories, and methods used in researching the area, and the unanswered questions. This will further enable the researcher to identify the importance of the study and to frame the argument accordingly. This implies that the literature review guides against researchers doing what others have already done.

Similarly, Naoum (2013) and Fisher (2012) observed that a literature review enables the researcher to build on existing knowledge and expand the scope of the present study. A literature review plays a major role in this study, by informing the research question, as well as the aim and objectives. For instance, the knowledge gap and research questions were partly identified from the literature, while the objects were supported by the literature review.

4.7.2 Survey questionnaire:

The word survey indicates human respondents and the basic data are gathered by talking to people, either over the Internet by written questionnaire, by telephone, or face-to-face. (Jankowicz, 2005). A questionnaire is a list of structured questions, which aims to find out what selected participants do, feel, or think and how they react (Collins & Hussey, 2003). The items in questionnaires can be divided into two types: closed questions and open-ended questions. In open-ended questions, a respondent can give a personal response or opinion, whereas in closed-ended questions, a respondent has to select an answer from a number of predetermined alternatives (Saunders et al., 2003). Closed type questionnaires could have a multiple-choice answer format or use rating scales, which allow a numerical value to be assigned to an opinion (Hussey & Hussey, 1997). A good questionnaire needs a careful design based on a thorough understanding of the research (Hackley, 2003).

Questionnaires allow for the collection of a large amount of data from a sizeable population in an economical way (Hussey & Hussey, 1997). Questionnaires are a popular method of collecting data, owing to the fact that they are cost effective and less time-consuming than interviews. On the other hand, they have drawbacks, such as non-response rates, which can affect any meaningful outcome (Saunders et al., 2003). Thus, the strategy is to collect the same information from the sample cases (Aldridge & Levine, 2001; Sapsford, 1999).

This study used a questionnaire as a tool to gain an understanding information concepts, and effective approaches and challenges to communication using technology. This was applied to a sample population in the UK construction industry. The aim of the questionnaire was to

collect a number of responses, although the main focus was on words rather than numeric data. Thus, the aim of the questionnaire was more qualitative than quantitative. Data collected from the questionnaire survey were analysed using a basic content analysis that was applied to the responses given. This particularly focused on the face validity of the items and the definitions and interpretations of terms. More inductive and comparative techniques were used to analyse the data, which allowed the researcher to elicit information from a larger geographical population in a shorter time than for an interview technique. In addition, this technique (known as 'questerview') allowed the participant to reply to the questions at their own convenience (Adamson et al., 2004). The researcher's decision was to use the questerview technique to consider the questionnaire as qualitative data. Questerview was developed from the literature review, enabling the development of open-ended flexible questions. Thus, the participants had space to add their contributions. The questionnaire included some open-ended and some closed questions, with the option to comment in order to add the participant's perspective. This helped to develop a background to support a literature review and considered the need for the study to focus on challenges that exist on most construction sites in the UK.

In this research, the literature review provided the basis and guidelines for the questionnaire design. The analysis of the literature review helped to highlight some factors that affect the effectiveness of communication on site, namely people and their organisational culture, technology and techniques, and information. It was envisaged that they would contribute to effective communication on site. The questionnaire was designed around the research questions and objectives, which were refined in consultation with the research supervisors. A detailed presentation of the research was discussed with a member of one of the construction company management team who was working as a communication manager in the UK and had five years experience in the industry. During the presentation, the questionnaire was discussed and reviewed to clarify any ambiguities and to leave comments and suggestions. In addition, the questionnaire was presented to two academic members at the University of Salford to elicit further comments and suggestions. These experts left some comments and suggestions related to rewording and reordering the questions. The amendments were made, and soft copies of the questionnaire were emailed to a couple of construction members to check the questionnaire time and quality. The comments and feedback given by members of industry were considered. The researcher prepared the final version of the questionnaire, which was to be conducted online using LinkedIn. This was emailed to site office teams where the researcher planned to conduct an observation. As the construction industry is a busy environment and employees

have limited time, the questionnaire was designed to be short (the expected completion time was 10 to 15 minutes). The researcher intended to ask participants their opinions, which could also be considered as a written interview. The main intention of the survey was to use the questionnaire as a written interview in order to secure a wider response. Thus, qualitative questionnaire data were considered and a description was gathered. The design of the questionnaire entailed open-ended questions, which helped to increase the chance of collecting more information and allowed participants the opportunity to add their own experiences.

4.7.2.1 Sampling strategy

Sampling has an important role when a survey is conducted on a product or situation that aims to capture the voices of a population. Often a set of individuals from that population will be investigated and that set is called a sample (Sarndal, 2003). Random and non-random are the two major forms of sampling. Random sampling considers that every individual in the population has the same chance of being selected, whereas in non-random sampling not all individuals have the same probability of being chosen (Lawton & Bass, 2006).

Survey questions can be categorised into two groups: closed or open-ended. The closed question option offers respondents a group of pre-set response choices, i.e. multiple choices. In the open-ended questionnaire, respondents have the liberty to respond in their own words and are not restricted to the pre-set choices offered by the researcher. Although closed questions may be simpler to convert to a numerical format, the questionnaire in this research was designed to use both close-ended and open-ended methods due to the need to develop an in-depth understanding of issues. This combination accorded with the aim and philosophical stance of this research.

Piloting helps to refine the questionnaire (Leung, 2001); this strategy could help to identify unanticipated issues with the questionnaire, such as structure and wording. In addition, it reveals whether participants understand the questions and whether the questions would yield useful answers. In this research, the questionnaire draft was presented to a member of a construction industry organisation who was working as a communication manager in the UK and had years of experience in the industry. They offered comments and suggestions. In addition, the questionnaire was presented to two academic members at the university to elicit further comments and suggestions. Those experts left comments related to the re-wording of important words for participants, which made the layout more attractive, removed redundant

queries and described key terms in the introduction. The next section discussed various quantitative analysis tests to identify the most appropriate statistical test for this research.

Non-random sampling was applied to this study due to the research limitations, such as cost, location and time, which prevented the researcher from applying random sampling. According to these limitations, the researcher selected individuals from the population who possessed the experience and knowledge required for this research area. The targeted sampling was purposive, which selects individuals who are willing to participate and have experience and knowledge related to a particular research domain. The targeted participants met the following criteria: working in construction companies based in the UK.

The questionnaire was conducted online by sharing the link with the management team of two main constructors in the UK. The researcher asked them to distribute the instrument to their team and to other stakeholders who worked with them, mainly their subcontractors. Also, to increase the response rate, the researcher distributed a link to the survey to number of construction parties whose LinkedIn profile pages met the criteria. They were identified by using a LinkedIn search filter. LinkedIn is a platform where different professional groups gather to share ideas and to network. In addition, the LinkedIn group named the UK Construction Network, that included engineers, clients, consultants, managers, design managers, and researchers, was selected to share the questionnaire. The researcher kept the questionnaire open for access for six months and regularly sent reminders to ask individuals to complete the questionnaire. At the time of analysis, 97 responses were received.

There are always limitations for researchers when collecting data from populations. Authors offer a number of recommendations for interpretivism, namely that researchers who collect their data from human interpretations should make their sample size reliable. Thus, the sample size should be optimised to ensure it reflects the specific context of the data. The optimum sample size should therefore represent a total population and the result should be generalizable to that population with minimum error. According to Takim et al. (2004), the AEC industry is non-supportive in responding to questionnaires; therefore, a 20% to 30% response rate is acceptable for analysis. The questionnaire sample applied in this research was determined by selecting relevant participants through LinkedIn. The web-based questionnaire was viewed by 390 respondents and 97 responses were received within six months; thus, the response rate was 0.24 %.

4.7.3 Interviews:

An interview is a method of collecting data in which selected participants are asked questions in order to find out what they do, think or feel (Hussey & Hussey, 1997). There are three basic types: unstructured, semi-structured and structured interviews (Fellow & Liu, 2008). Unstructured interviews are based on questions that are not planned, when the interviewer has to rely on his or her interview experience to extemporise. The advantage of this approach is that it takes little time to prepare, while the disadvantages are that important issues may remain unexplored and inappropriate questions may be asked on the spur of the moment.

An interview is a purposeful discussion between two or more people (Kahn et al., 2002; Saunders et al. 2011; Silverman, 2007). The method helps in gathering valid and reliable data relevant to the research questions and objectives (Saunders et al., 2011). Interviews are usually classified according to the degree of structure. Hence, they are classified as; structured (standardised), semi-structured (non-standardised), and unstructured (non-standardised, in-depth). Semi-structured and unstructured interviews are referred to as qualitative research interviews. Table 4-7 summarises the various types of interview for different types of research study,

	Type of Study	Guidance & Preparation
Structured	Descriptive ✔ ✔ Explanatory ✔	Detailed interview schedule: Questions in a predefined order, some of them are close-ended.
Semi-Structured	Exploratory ✔ Explanatory ✔ ✔	Topic guide: selection of topics or issues to be covered.
Unstructured	Exploratory ✔ ✔	No interview schedule or guide. Individual questions simulate an informal conversation.

Table 4-7 Uses of different types of interviews (Source: Saunders et al., 2009)

Key: ✔ = less frequent ✔ ✔ = more frequent

4.7.3.1 Unstructured interviews

Minichiello et al. (1990) defined the unstructured interview that in which neither the question nor the answer categories are predetermined. Instead, they rely on social interactions between

the researcher and the informant. Punch (1998) described unstructured interviews as a way to understand the complex behaviour of people without imposing any a priori categorisation that might limit the field of inquiry. Patton (2005) described unstructured interviews as a natural extension of participant observation because they so often occur as part of the ongoing participant observation fieldwork. He argued that they rely entirely on the spontaneous generation of questions in the natural flow of a conversation.

Although unstructured interviews do not use predefined questions, they are not necessarily random and non-directive. Unstructured interviews require detailed knowledge and preparation in order to achieve deep insights into people's lives (Patton, 2005). The researcher will keep in mind the study's purpose and the general scope of the issues to discuss in the interview (Fife, 2005). The researcher's control over the conversation is minimal, but interviewees will be encouraged to relate experiences and perspectives that are relevant to the problems of interest to the researcher (Burgess, 1982).

Unstructured interviews can be very useful in studying people's behaviours and perceptions. They are especially useful for attempts to identify patterns, generate models, and to inform information system design and implementation. For example, Alvarez and Urla (2002) used unstructured interviews to elicit information requirements during the implementation of an enterprise resource planning system. Unstructured interviews can be used to examine people's information activities in settings where it is inappropriate or impossible to use other, more structured methods. In this study, the researchers used unstructured interviews alongside observations in order to collect as much participant information as possible. The research did not use a set of questions; however, questions were asked in a systemic way to ensure that they covered all the concepts that resulted from the descriptive study.

Easterby-Smith et al. (2015) used the degree to which the researcher is engaged or detached from the researcher-subject as an extra dimension in a research philosophy. In their view, most schools of thought that follow a constructionist philosophy see the researcher as engaged in the research. Cicmil (2006) also concluded that, by using active interviewing, researchers can generate an alternative understanding of what goes on in practice. Therefore, being an active interviewer means that the researcher has undertaken the following (Holstein & Gubrium, 1995):

- The researcher (interviewer) provided prompts in various ways to encourage respondents' narratives. This was a way of conveying to the respondent that the

researcher was sensitive to, or interested in, certain narratives or topics.

- The researcher asked the interviewee to shift their narrative position, i.e. to look at the issue from one point of view and then from another. This explored the various ways in which the respondent attached meaning to a subject. Positional shifts can extract contradictions and complexities.
- The researcher asked questions about the respondent's experience and background knowledge. This background knowledge allowed the researcher to better understand and interpret the vocabulary through which the respondents' experience was conveyed.

Most interviews were designed to take up to 60 minutes. However, some were shorter, and others were longer according to participants' time constraints. Conversations flowed in a smooth manner and the researcher was able to provide a comfortable atmosphere where none of the respondents felt embarrassed or at risk of disclosing sensitive information.

The unstructured interviews were a natural extension of the participant observation as they occurred as part of the ongoing participant observation fieldwork. The researcher came to the interview with no predefined theoretical framework, but held conversations with interviewees and generated questions in response to the interviewees' narrations. As the interviews were open-ended and the questions depended on the participants' answers, this process was guided by the interviewer to ensure coverage of the research topic; however, there was no existing set of questions.

Instead, the interview started with questions that asked about the interviewee's point of view on the communicating approaches that occur in their site offices. From this, follow up questions were asked about other areas in order to start conversations about:

- How information is exchanged on site;
- What participants thought about the use of mobile technology on site;
- How they would describe the relationship between the main and subcontractors, and how this could be improved.

These started the interview process and subsequent questions were varied depending on the responses offered.

4.7.3.2 Sampling

Sampling strategies provide a variety of methods that reduce the amount of data required by considering only data from a sub-group rather than all possible cases. Non-probabilistic sampling tends to be used in qualitative research whilst probabilistic sampling, is mostly used in quantitative research and adheres to a number of rigorous rules (Easterby-Smith et al., 2008; Saunders et al., 2012). Figure 4-3 classifies the different probabilistic and non-probabilistic sampling strategies.

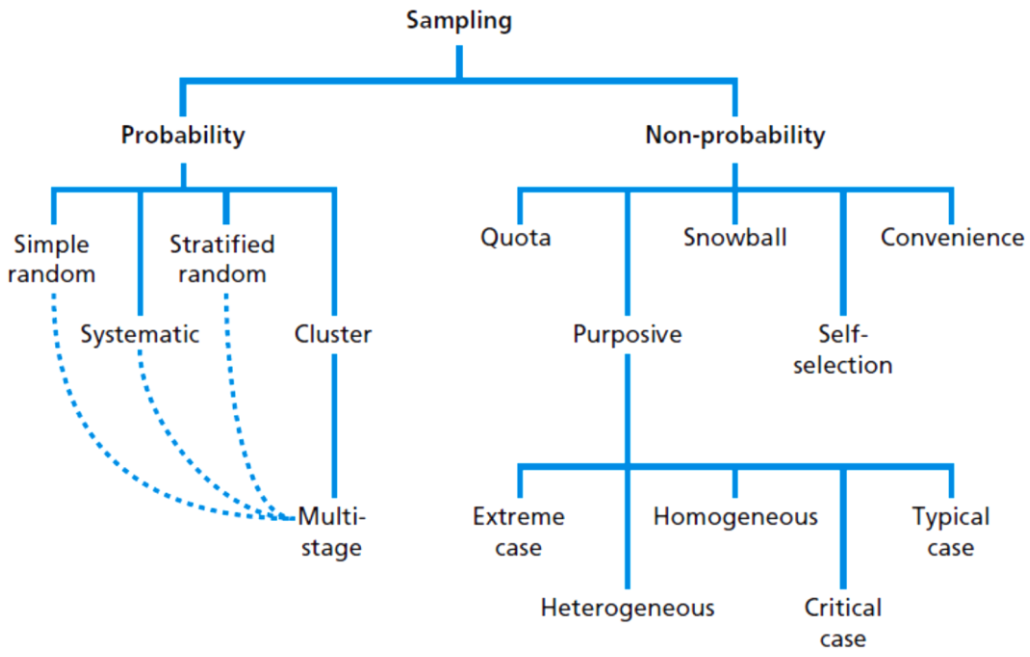


Figure 4-3 Sampling Strategies (Source: Saunders et al., 2012)

Non-probabilistic sampling aims to identify, "reasonable instances of the larger phenomena under study" (Easterby-Smith et al., 2015). It seeks to select a purposeful sample that is relevant to the research questions. The classification of non-probabilistic sampling and the labels used to describe sampling strategies differ from one author to another. For example, peripheral sampling was discussed by Miles and Huberman (1994), but not in more recent texts on methodology, such as those by Easterby-Smith et al. (2015) and Saunders et al. (2011). It could be argued that peripheral sampling has some similarities with the heterogeneous sampling defined by Saunders et al. (2011) in that it brings varied cases. Table 4-8 shows some of the sampling strategies used in this research, compiled from Bryman (2012), Easterby-Smith et al

(2015), and Miles & Huberman (1994). Easterby-Smith et al. (2015) state that most researchers design a sampling plan based on one or two strategies.

Sampling Strategy	Procedure and Purpose
Ad-hoc or convenient sampling	Cases are selected based on availability and accessibility. This strategy is followed when the priority is the speed of data collection.
Purposive (typical case) sampling	Identifies the most typical instances
Peripheral sampling	Involves speaking to people who are not central to the phenomenon but are close to it. The aim is to gain a deeper understanding of the research through comparison and contrasts

Table 4-8 Non-probabilistic sampling strategies

In this research, the sampling strategy mainly involved ad-hoc or convenience sampling as the researcher interviewed the site teams where the observation took place. This thesis identified three subjects, constituting three levels of analysis, for consideration within the data collection, namely roles, organisation, and tools. Therefore, the sample selection was filtered through the three levels of analysis before the interviewees were selected. Although three levels of analysis were considered, this thesis specifically focuses on the inter-organisational level.

- **Sampling size:**

Saunders et al. (2011) believe that there are no rules to decide the sample size in non-probabilistic sampling. Instead, they state that it is important to consider the logical relationship between the sampling strategy and the purpose of the research (Saunders et al., 2011).

Conducting an unstructured interview:

There are no official and agreed-upon guidelines for how to conduct an unstructured interview. However, in practice, many researchers comply with the steps outlined by Punch (2005) and Fontana and Frey (2005) when planning and conducting unstructured interviews, which are: getting in; understanding the culture of the interviewees; deciding on how to present oneself; locating an informant (i.e., the interviewee); gaining trust and establishing rapport; and capturing the data.

The researcher needs to take brief notes during the interview, and to write up more detailed notes immediately after each interview; it is also advised to record the interview where possible

(Fontana & Frey, 2005; Lofland, et al., 2006). It is recognised that, as the researcher develops their interviewing skills, they may want to practice a variety of memory techniques, in order to be able to capture as much detail as possible from each interview. As the researcher conducted observations on the site and conducted an interview with the site team members, a sense of relationship and trust had already been established.

4.7.4 Observation:

Observation is linked to longitudinal studies where a group or work setting is observed by the researcher over a (typically long) period of time (Gray, 2013). There are two types of observation: participant and non-participant. In participant observation, the researcher is required to immerse themselves within the observed group or setting and to participate in the group processes whilst also capturing observations, and recording with the use of a diary, camera, notes and so forth (Creswell, 2009). In contrast, a non-participant observer will not participate with the group in any activity during the observation of the group or setting. Non-participant observation allows more time for the researcher to observe objectively (Perera et al., 1995). This enables the researcher to make plenty of observation notes because of the low level of involvement in the observed community. This is essential in the analysis phase, when it is important to remain informed about the subjects of the study. This type of observation could enable the researcher to shape the data collection whilst the data collection is in progress.

Researchers adopt observational research to discover new theories, rather than confirm or support existing theories. According to Gray (2013), researchers use observational research to try to understand human action or the processes being studied. They do this by entering, as far as possible, the worlds of those they are trying to understand (Gray, 2013). An observer can take either overt or covert approaches during observational research. Overt observation (open observation) is an approach where those being observed are aware of the observation and the presence of the observer, whilst covert (hidden) observation means they are unaware that the observation is taking place (Robson, 2016). This research involved open observation, which was agreed between the researcher and the on site project manager. The observation can be categorised as follows: notes on interviews; notes on event observations; notes on developing research thinking; and notes on events (i.e. meetings attended).

This was undertaken in a systematic manner in relation to the identified information, communicators and the use of available technology. The aim was to gain an understanding of the challenges so as to identify the level of use of informal and formal communication in UK

site offices. Rather than relying on information from a questionnaire survey, Bryman (2012) states that structured observation directly identifies behaviour or practice, which improves the quality of the data collected. Also, Cooper and Schindler (2008) confirmed that structured observation is used when a study intends to answer a research question and usually provides a valid and reliable account of what happened. It could be used as a primary method or to supplement other methods.

In this research, observation was conducted at the site offices of two main contractor companies who were delivering building construction projects in the UK. Non-participatory observation is also known as systematic observation; it is an approach used to record behaviour or practice (Bryman, 2012). The aim of the observation is to enable the study to aggregate the current practice of communication methods within on-site offices. The researcher managed to conduct non-participant observation by attending meetings and discussions with the participants on the sites; the observation period lasted for five months, and the researcher was on each site for two to three days per week.

4.7.5 Data Analysis Methods:

This section aims to provide a theoretical overview of the methods used to analyse data. The application of these methods is detailed in Chapters Five and Six. In conducting the analysis, the researcher was largely influenced by three main authors, namely Creswell (2009), Easterby-Smith et al. (2008), and Miles and Huberman (1994). Data analysis includes the interpretation of the data collected during the research inquiry (Patton, 2005). The data analysis phase usually begins after starting the data collection. In certain instances, researchers may decide not to start the data analysis until the data collection has ended. However, it is better practice to start the data analysis and collection concurrently (Miles & Huberman, 1994; Saldaña, 2012). Miles and Huberman (1994) described the analysis process as recursive and dynamic because it occurs before, during and after the data collection.

Data analysis can be divided into three steps: (1) preparing the data for analysis, (2) analysing the data, and (3) interpreting the data (Marczyk et al., 2005). Preparing the data for analysis includes: organising the data, breaking them into smaller units, and sorting. Analysing the data includes: searching for patterns, highlighting similarities and variations, explaining them, and synthesising them. Interpreting data includes connecting themes and codes, linking the data to theory, and writing about the data.

4.7.5.1 *Data Preparation:*

Interviews were audio recorded, so the first step in the analysis involved the transcription of all interviews using Microsoft Word. The researcher prepared the transcripts by organising the paragraphs and breaking bigger ones into smaller chunks of text (Miles & Huberman, 1994). The researcher then read through all transcripts to ensure they were ready for analysis.

4.7.5.2 *Data Analysis:*

Inductive-abductive thinking underpinned the research inquiry to interpret the data obtained and to rigorously structure the research. The researcher started with a basic framework; this was informed by the literature review and research questions, which assumed that the main challenges to effective communication are people, technology, and information. Moreover, the aim was to understand how they linked on-site offices to ensure accurate and timely information. The researcher's assumptions provided a focus for the study and an abstract overview of the interrelated variables. However, the conceptual understanding extracted from the literature review provided abstract inferential conceptions of the relationship between information, technology, and communication, the dimensions this reciprocal exchange holds, and how the communication process engages with reciprocity. The coding system relied, to a certain degree, on this minimal framework, which has been developed in parallel with the observations to break down the aspects to more specific points.

Thus, a purely inductive approach does not use a pre-defined framework to analyse data and make it fit with the framework. Codes are not pre-determined but rather emerge while reading the transcripts. The researcher agrees with Creswell (2009) that codes have several types; some are expected whilst others are surprising and unanticipated. The researcher was flexible enough to look for, and accommodate, emerging and surprising codes.

4.7.5.2.1 Thematic analysis:

In adopting a different classification to Easterby-Smith et al. (2008), Maxwell (2008), categorised the analysis strategies into three groups:

- Categorising strategies, such as thematic analysis,
- Connecting strategies, such as narrative analysis and individual case study,
- Memos and displays.

To conduct thematic analysis, codes should first be located and defined (Miles & Huberman, 1994). Thematic analysis involves reading and re-reading the transcripts in order to arrange and re-arrange data into codes that, taken collectively, form themes (Creswell, 2009). Defining a theme correctly means that the researcher could provide evidence to a given theme within the text in transcripts (Guest et al., 2006). The main purpose of the thematic analysis is to locate variations and regularities within and across themes (Maxwell, 2008). In this sense, it is most suitable for semi-structured, open-ended interviews (Burnard, 1991).

However, Bryman (2012) criticised the classification of thematic analysis as a data analysis strategy, arguing that it is not an approach for analysis; it does not have an 'identifiable heritage', and it "has not been outlined in terms of a distinctive cluster of techniques". The researcher noted a similar observation while reviewing texts on qualitative methodology (e.g. Creswell, 2009; Easterby-Smith et al., 2008; Saunders et al., 2011). All these texts refer to thematic analysis as a step that is undertaken in most analysis strategies. Whilst Bryman (2012) did not acknowledge this in previous editions of his book, he has since done so in the latest edition with extensive references to thematic analysis in the literature (Bryman, 2012). The researcher, while reading the data, has looked for the patterns, similarities and key topics. In doing so, codes and themes were generated, and data were synthesised.

4.7.5.2.2 Coding:

A code is a word or short phrase that captures the essence of the topic (Creswell, 2009). Coding is the first step in performing thematic analysis. Themes are regarded as the highest level of coding; they are a formal rendering of codes (Guest et al., 2006). Codes are applied to data whereas themes emerge from data. The purpose of coding is the organisation of data that makes data retrieval possible (Miles & Huberman, 1994). Additionally, codes can be used as an indication of saturation. When the data did not yield any more new codes, and the definition of the codes had stabilised, saturation was achieved (Guest et al., 2006). Easterby-Smith et al. (2008) and Saldaña (2012) classified the process of coding into three levels as shown in Figure 4-4:

- Level 1: codes
- Level 2: subcategory
- Level 3: category

Themes are the collection of different categories. Theory is then generated from the collection of different themes.

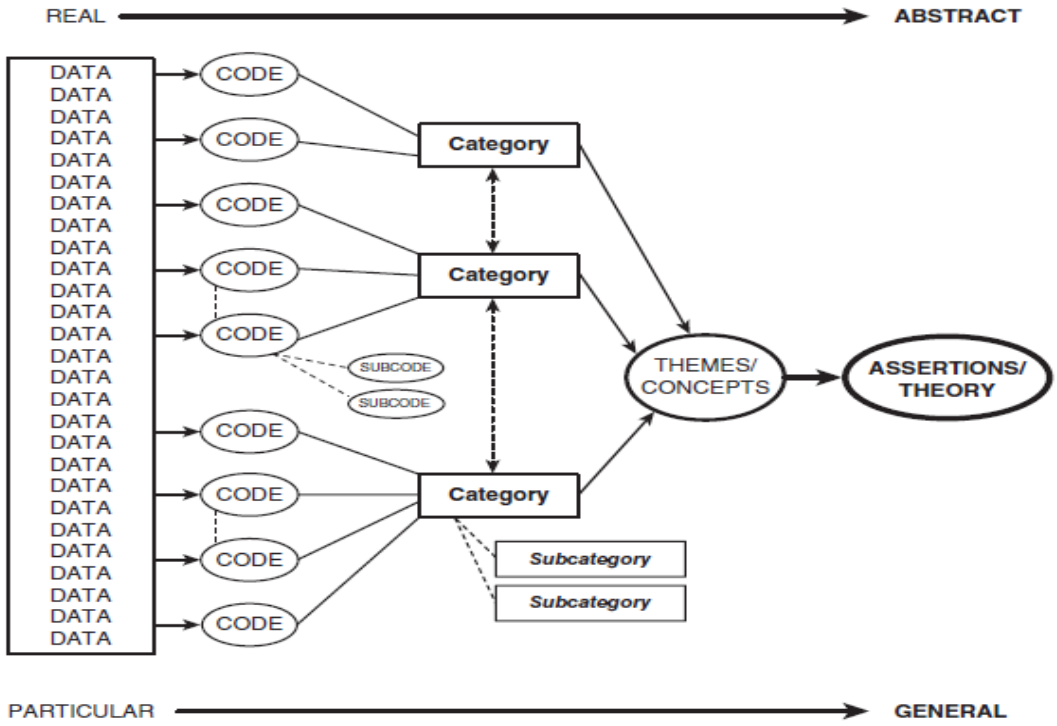


Figure 4-4 Coding Levels. (Source: Saldana, 2012)

These correspond with Miles and Huberman's (1994) classification of codes, which are:

- Descriptive: broad, abstract, and requiring little interpretation (early iterations of analysis)
- Interpretive: emerging from analysis
- Pattern: inferential and explaining the higher-level codes, they are effectively emerging themes.

Thus, both Easterby-Smith et al. (2008) and Miles and Huberman (1994) outlined coding structures. The subsequent sections in the chapter refers to this by illustrating emerging codes and themes. Furthermore, Creswell (2009) listed several types of codes, and these are shown in Table 4-9 with an example of the coding used for the data collection.

Code Type	Example of level one codes
Setting/Context	Main contractor, subcontractor, size
Technology	Emails, WDC, phone, radio
Process	Disrepute, inspection, RFI, change

Strategy	Board, meeting, email, paper-based, WDC, calls
Relationships	Trust, personality, knowledge, conflict

Table 4-9 Types of codes and examples from the data collected

It is important to note that the coding was conducted in cycles (iterative process) that involved re-reading and re-defining the codes until the final definition was reached. Throughout the coding process, some codes decayed, whilst others appeared to be an ill fit for the materials. Others proved to be very popular within the data, pulling together too many segments. According to Easterby-Smith et al. (2008) and Miles and Huberman (1994), these codes appeared to be level 2 or 3 and were broken down further into level 1 codes. Coding is complete when all text segments have been coded and classified, and a sufficient numbers of regularities (themes) have emerged (Miles & Huberman, 1994).

4.7.6 An example of research coding:

The three levels of the coding process used descriptive, interpretative and pattern (themes) codes. The basic framework elements, namely people, technologies, and information, acted as containers for the themes. In coding language, these elements are positioned at higher-level themes, which lead to the interpretation stage. An example of the codes that fed into the people elements are shown in Table 4-10. Examples of the data chunks that were coded using some of these codes are presented in Table 4-11. The researcher expected a number of codes to appear in the data, which could be aggregated upwards to feed into either one of these elements. The researcher was fairly flexible in allowing for new codes and themes to emerge; it is important to note that some data chunks were coded at more than one code.

The columns in Table 4-10 reflect the three levels of coding previously described; however, the three-level hierarchy was not strictly followed. For example, Level 0 was used to indicate sub-codes, although these were not necessary for all data. The majority of the data were coded directly into Level 1. Similarly, some data chunks were themes on their own, whilst words highlighted in bold blue were emerging codes or themes that the researcher did not expect to appear.

Level 0: Sub-code	Level 1: Code	Level 2: Category	Level 3: Theme	Framework Element
Decision making		Performance	Perceptions	PEOPLE

Environment				
Prioritisation				
Information accessibility		Limitation		
Time				
Change	Information process			
Request				
Approved				
External team				
Complexity				
Their Role				
Generation				
Main/sub contractor			Background	
Contract regulation				
Exchange knowledge			Learning	
Work environment				
Sharing information			Relationships	
Method of communication		Communication skills		
Manager	Power-Relations			
Trust				
Management structure				
Top management support				
Personality				
Inspections			Motivation	
Project time				
Progress reports				
Completion				

Personal Development		
Experience	Resources	
Training		
Material		
Mistakes feedback		
Information flow		

Table 4-10 Coding structure for the people element

Data	Code	Category	Theme
"I think having an open plan site office when everyone could easily ask or share what they think with the team help to increase the collaboration between the team member, have this type of the environment could limit the security of some information!"	Environment	Performance	Perceptions
"The minute you start having a situation in the site when changes need to be done in certain time and send to be approved and you need to continue doing the rest of tasks safely, so you've got to balance the time to do things and how to communicate to get the right data on time, you've got to prioritise."	Prioritisation	Performance	Perceptions
"… when things had to be agreed on site between the main contractor and sub-contractor. It should be taken on board even if it is verbal agreement to build up a trust relationship. However, things need to be documented"	Trust	Relationships	
"Now we have an agreement or we have negotiated so that if one of the subcontractors still submitting the job later than the agreement, the main contractor need to arrange a meeting to negotiate the options to push the work forward or just have a claim according to the contract. If you communicate with the subcontractor on the right time you could reduce the need to claim because you are putting everything in place."	Negotiation	Relationships	

"… one of the things that sub-contractor face is having limited access to the information from the site itself as they do not have a supervisor which push them to ask the main contractor to get a hard copy. Therefore, the time they need to have the right updated information would be doubled."	Sub-contractor	Background

Table 4-11 Examples of codes, categories, and themes for the element: People

4.7.7 Data Interpretation:

Creswell (2009) defined data interpretation as an ongoing process involving continual reflection. It involves either:

a. Finding the meanings of data, lessons learned and the researcher's personal interpretation.
b. Comparing the findings from the analysis with information collected from the literature or linking the data to theory.

The findings, in this case, will either:

- Confirm or diverge from past information.
- Suggest new (emergent) questions that need to be asked.

Although the coding level implies a sequential order to the data analysis, it is usually done in an iterative and reflective manner. Miles and Huberman (1994) provided a useful depiction of the timing of the data analysis steps, showing the overlap between these steps (Figure 4-5). Indeed, the researcher started the first cycle of coding and interpretation immediately after the first interview. However, most of these codes and interpretations were developed and/or changed as further interviews were conducted. Thus, the anticipatory stage indicates the basic framework (and the resulting initial codes) that the researcher uses as a result of the exploratory and descriptive study.

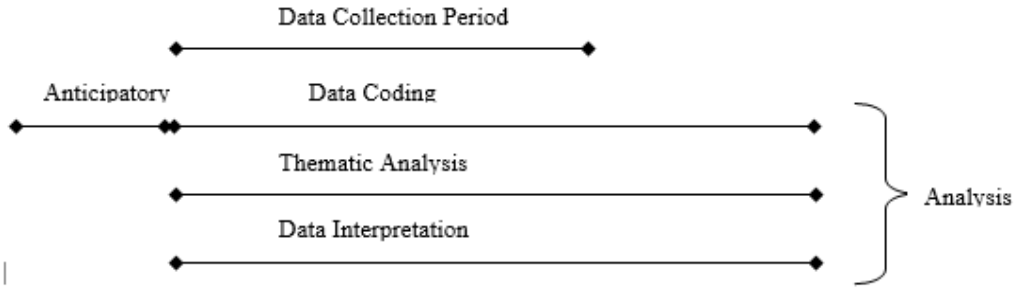


Figure 4-5 Overlapping Analysis Stages (Source: adapted from Miles and Huberman, 1994)

4.8 The intersection between data:

The data were qualitative; however, the data set included two sub-types, which were not easily distinguishable. In order to ensure a greater understanding of the UK construction communication culture, the researcher chose to link the literature review, observation documents and questionnaire data; these were considered secondary data during the interview and observation analysis.

The first type of data is from the questionnaire, which provided a supportive background understanding of the site environment. The survey was developed to answer a set of questions that reflected communication on site. This aimed to understand: the type of information used, how to communicate it this information, the tools employed, the people who work on construction sites, and the knowledge, experience, and roles of such individuals. This addressed the technology used and participants' perceptions of site communication. The results of this survey were used to back up the research information and the study's aim. The survey was considered the first phase of the data analysis in that it linked with the rest of the secondary data.

The second type of data involved observations, which took place in the site offices, and interviews with on site team members who were observed. The intention in gathering these data was to ensure a deep understanding of their points of view about communication on site, attendance at meetings, views on technology, and shared document controls. This helped the researcher to understand how information could be exchanged, updated and communicated. The researcher categorised the media used onsite; for example, meetings methods were observed, which examined aspects related to communication improvements, the meeting times, people who attend the meeting, the meeting type and agenda, the information shared, and type of technology used or that could be used. To view the information aspect of communication,

the researcher examined the methodology the team used to share and exchange site information. The researcher looked at the tools through which information was shared, such as document servers. The observation focused on who had access to this information, how it was shared, how it was updated, where it was used, from where it could be accessed, and how it was adopted. The researcher observed the tools and methods used to move information to the site in order to build the project. The unstructured interviews met the basic objective of the research methodology in seeking participants' perceptions, meanings, and methods. This distinction is not meant to isolate individuals' perceptions but rather to link their perceptions and behaviours to the complexities of site communication. In addition, spending time on site helps to ensure a better understanding of the site office environment and the impact, whether direct or indirect, on the project process. These perceptions are considered primary data since the researcher was only able to secure them through the conduct of the interviews and observations.

The main points of the observation and interviews were to understand:

- The nature of the communication and the methods used in site offices
- How the communication methods were perceived, and why communication was perceived by respondents as effective
- The technology used in the site office and the site itself, to what level it had been used and factors that obstructed the use of (mobile) technology on site.
- The environment and culture of the site office and how it affects the process.
- The people who work on-site, and how they communicate, the nature of their relationships, how they request and update data, and the way in which they take it to the activity level to build the project.
- How the information moves through the main contractor to the subcontractor and then to the build on site.

The majority of the data was classed under the perception sub-type because most questions started with 'what do you think of' and 'what is your opinion'. However, since part of the primary data was fact-related, such as the information needed to do the job, some of the findings will be descriptive of these facts and events, and not identified within the literature review. Furthermore, in discussing the primary data findings, reference is made to secondary data for comparisons that enable triangulation.

4.9 Credibility of the Research:

Judging the credibility of research depends on the epistemological position of the research itself (Easterby-Smith et al., 2015). A constructionist view is not concerned with proving a single truth. Thus, rather than questioning the ability to prove research results, the notion of credibility in qualitative, interpretative research asks questions regarding trustworthiness and the relevance of the design and research process (Cicmil, 2006; Guba & Lincoln, 1994; Seale, 1999). Questions of credibility in qualitative research relate to the validity, reliability, and generalisability of the research outcomes (Cicmil, 2006).

The reliability of data can be translated into consistency throughout the research process (Bryman, 2012). This means the same definitions/terms should be used in conducting interviews. For example, it had been made clear to interviewees that the term 'site offices' encompasses both the 'main contractor' and 'subcontractor' environment. Thus, when they needed to make a distinction, the researcher confirmed the term with the interviewee to ensure that an accurate term was captured. The final definition of codes was kept consistent throughout the analysis. In fact, the risk of inconsistency is generally higher when the research involves a team of researchers observing the same phenomena and analysing the same data set, i.e. coding and interpreting (Creswell, 2009). This risk was not encountered in this research since it was conducted and analysed by a single researcher.

The validity of the data can be evaluated by several means. As a measure of constructionist research validity, Easterby-Smith et al. (2015) asked whether a sufficient number of perspectives have been included. The sampling strategy for this research has prioritised access to all possible perspectives on challenges. Different groups (stakeholders) have been identified and individuals representing these groups have been selected.

Triangulation is a technique to ensure qualitative data validity (Creswell, 2009; Easterby-Smith et al., 2015). The principle seeks at least three ways to verify or corroborate a particular event, description, or fact reported by a study (Yin, 2010). Through the three stages of exploration, description, and explanation, this research relied on three sources of evidence, namely triangulation. The findings of the interview analysis are compared to the survey as well as the theoretical data in the field of construction organisation communication. This comparison enables the validation of the literature findings and a reflection on communication theory. Therefore, triangulation is conducted throughout the study as a whole. This is supported by Yin

(2010) who stated that, although in practice triangulation tends to be associated with the data collection phase, it can be applied throughout the study.

A common critique is that purposive sampling provides a low degree of generalizability. This is a basic critique to non-probabilistic sampling, specifically, and to qualitative inquiry in general (Creswell, 2009; Saunders et al., 2011). However, in qualitative, theory-building research, generalisation is made to theory rather than to the population (Saunders et al., 2011). Cicmil (2006) offered a general description of credible qualitative research that is objective in considering honesty, ethics, and high moral standards. In this regard, the ethical considerations of this research are discussed in the following section.

4.10 Ethical Considerations:

The need for ethical consideration was suggested by Bryman (2012), and required by the University of Salford. Thus, ethical approval was sought and given from the University of Salford's Ethics Committee with a full description of the proposed study. Following ethical approval from the committee, the invitation/consent letter to participate in the research interviews and site observations were sent. A copy of the invitation letter to participate in the interview was sent by email to each of the respondents and the arrangements for interviews were made following a formal response expressing an interest in participating in the study. This stage was essential as it assured respondents of the confidentiality of their responses.

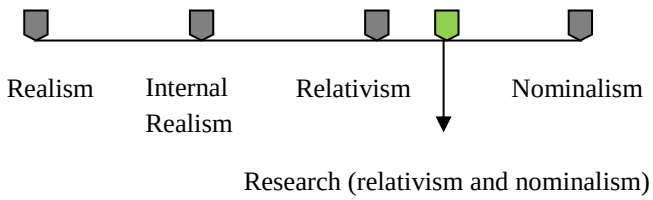
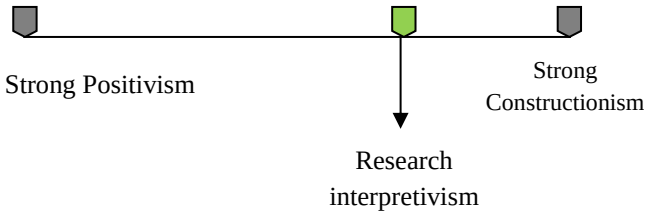
Interviews were recorded on a digital device and transferred to local computers located at the University of Salford. Original records on the digital device were destroyed and only those on the university computers remained. These were saved in an encrypted folder. The transcripts were also saved on the University managed computers. All files were encrypted to the fullest extent of the data protection enabled by the IT services at the University of Salford. Any published or unpublished work anonymised the identity of participants. Only the transcripts showed the identity of the participants. The transcripts were saved under lock and key in the filing cabinets supplied by the University and only accessed by the researcher and supervisor. Therefore, any published or unpublished work (for example, journal articles and annual progression reports) would never disclose the identity or personal details of participants. During the course of the interview, participants were notified of the possibility of quoting sections of their transcribed interviews and were given discretion to agree or disagree.

4.11 Limitations of the research related to methodology:

Several limitations of this thesis require discussion, and first amongst these is the methodology. Although this thesis employed questionnaires, interviews, and non-participant observation, it largely relied on unstructured interviews for the collection and analysis of data. The researcher acknowledges that a reciprocal exchange that is heavily based on social interaction necessitates more observation. The time constraints to accomplish the data collection for a PhD project represented an obstacle, as construction projects span long periods of time. Therefore, it would take longer than the typical span of a PhD data collection phase to conduct such longitudinal research. The observation took place in two of construction sites within a limited time; the research could not cover all aspects related to communication in detail as it is changeable. The results of the research were therefore limited to the data collected and do not reflect a general overview.

4.12 Summary:

Table 4-12 summarises the methodology described in this chapter.

Ontology: nature of reality	
Epistemology: nature of knowledge	
Research Approach	
Type of Research Problem/Question	Providing an in-depth understanding of challenges to effective communication within on-site offices.

Research Design	Qualitative using case study design
Research Study Type	Exploratory & descriptive: based on the literature review and questionnaires to find the aspect that reflects on site communication Explanatory: using observation and interviews to study the challenges based on the descriptive understanding.
Theory	Using the lens of communication barriers from the basic framework to examine the aspects that impact it, analysing: • People as the main contractor and subcontractor • Information exchanged on site • Available technology
Methods: Data Collection	Questionnaire, observation, and unstructured interviews
Data Validation Procedures	Triangulation of three sources of evidence: the theory (literature), questionnaire data, and observation (interview) data.
Data Analysis	Thematic analysis: coding & themes, generating meanings from the data.

Table 4-12 Methodology

5 Chapter Five: Phase One - Questionnaire

Chapter Four highlighted the theoretical principles and steps adopted in the data analysis, while this chapter provides the data analysis itself. The chapter offers an analysis of the first phase of the primary data and links codes to the basic framework (people, technology, and information) that emerged from the literature review (Chapters Two and Three). This chapter includes a description of the questionnaire survey analyses, which were based on participants' replies. A summary of the questionnaire results is provided at the end of the chapter.

5.1 DATA COLLECTION AND ANALYSIS

5.1.1 Introduction

The design of the questionnaire survey was based on the literature and aimed to achieve a wider perspective on communication and information exchange in the UK construction industry, including an understanding of the current communication challenges. It also intended to elicit suggestions to improve the efficiency of communication on construction sites. The main reason for adopting a questionnaire is to consult a larger number of responses in order to: firstly, develop a more accurate understanding of how information is exchanged on site; secondly to determine the methods of communication used; and finally, to understand the extent to which technology is used to communicate and exchange information.

5.1.2 Research Planning and Designing

The survey was designed to cover many points directly related to communication, including: information sharing, standard forms or reports that affect information exchange, the method of information exchange, ways of communicating, the need to use mobile technology on site, and the communication barriers and issues that prevent effective communication. The analysis and findings presented in this chapter follow the structure of the survey (See Appendix A for a copy of the survey).

This questionnaire adopted an open-ended design, which allowed participants to add other options, information or methods that they experienced in their organisations but were not included in range of responses offered. The aim was to understand information identified within site offices that could be used as a wider reflection of communication within the UK construction industry. Achieving this aim would increase the validity and reliability of this

study. The analysis and findings of the questionnaire survey are presented in five sections, as follows;

- Demographics of the survey sample
- Information management issues of the survey sample
- The relationship between the site information and communication methods
- The site office
- Communication barriers
- Mobile technology on site

5.1.3 Demographics of the Survey Sample

This section presents the data analysis from the questionnaire. The demographic data provide a descriptive statistical study of the population, presenting the key characteristics and a summary of the sample. The demographic data presents a clear view of the background experience of the participants in the construction industry, the size of their organisation, the type of work undertaken by their organisation, their job title, the number of operatives at the site, and how knowledgeable they feel about their tasks. This phase of the study required data that related to the site office, including information on site and the people working there. It also involved the examination of relationships, information flow and communication methods. Accordingly, the size and type of the organisation was important. To increase the likelihood of securing UK participants, the researcher shared the link with two UK construction sites. Moreover, the subsequent observations took place in the main contractor site offices.

The results of this questionnaire were varied in terms of the organisations' backgrounds. The majority of participants (40.54% of the overall sample) worked for a main contractor in the UK industry. This was followed by subcontractors (at 24.23%), who were responsible for undertaking work on behalf of the main contractors. Finally, construction consultancies (21.62%), clients (10.81%) and project management (2.7%) comprised the smaller proportions of the overall sample. Figure 5.1 illustrates that almost three-quarters of participants were main contractors or subcontractors who worked on the site and were involved in building the project. This suggests the reliability of the data collected from the survey, and thus enables an accurate exploration of the communication issues from the perspective of the main contractor.

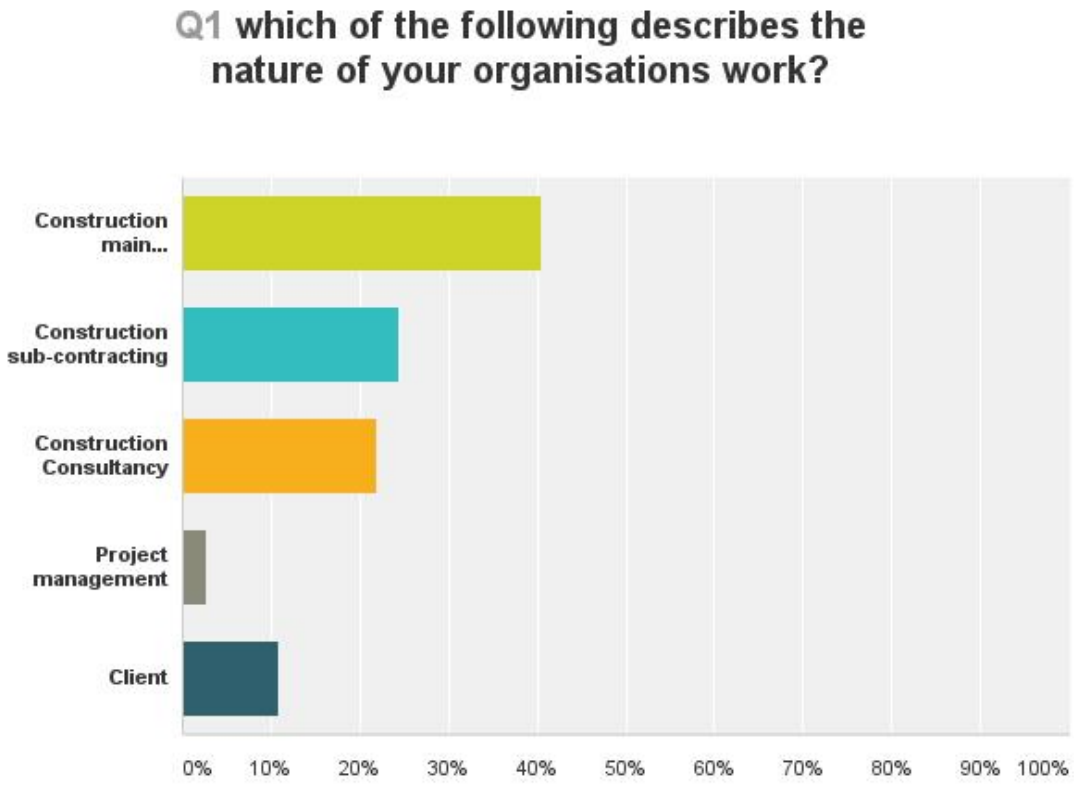


Figure 5-1 The background of participants' organisations.

The main contractor teams are targeted in this questionnaire, as they are the main controllers of the site information and responsible for its management. These also comprise the greatest share of participant responses. The subcontractors deal with information at the construction stage on site. Considering another user in this phase of the study helped to establish an overall understanding of the site office environment.

In construction, many organisations have to work together in order to deliver a project on time to a high quality. This highlights the importance of the second figure, which is the size of the organisation. As shown in Figure 5.2, from a total of 97 participants, most organisations are considerably large. Small size organisations are those with less than 50 employees, while medium size organisations employ between 50 to 100 personnel and large organisations are considered to have more than 100 employees (Hall et al., 1967). Within the sample, organisations with >2000 and >1000 employees comprise the same proportion at 27.03%. The other organisation sizes are as follows; <500 at 13.51%, <100 at 13.51% and <50 at 18.925. Figure 5.2 shows the range of organisation sizes within the sample; it reflects all sizes, which mostly refers to subcontractors who work on a construction site.

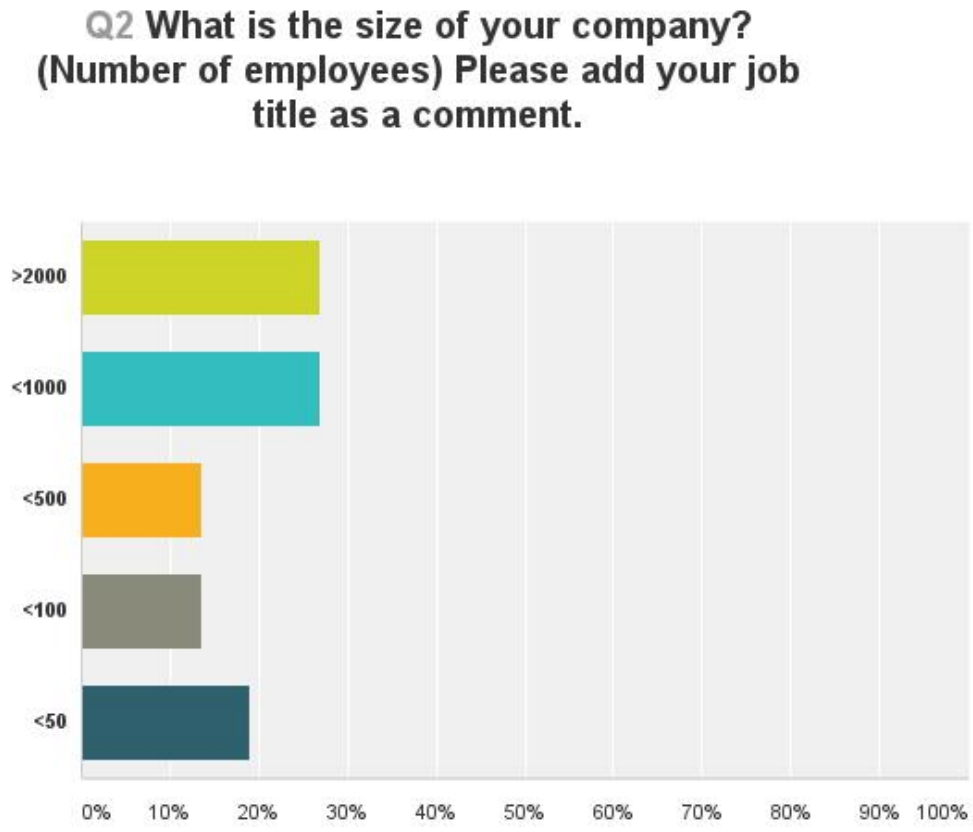


Figure 5-2: The size of the organisation

The second part of the demographic sample relates to organisation sizes, which is an integral part of this survey analysis. Consulting participants from large organisations increases the reliability of this survey as larger organisations mean more complex projects and communication systems. Large organisations will have more up to date technologies and methods to communicate and exchange information. At the same time, they have more conflicts to address, which means they provide an appropriate context in which to consider and understand communication on a construction site.

Therefore, the research focuses on the site and includes a number of operatives for each organisation on a single site; gathering this data is important in understanding the complexity of a project and the relationships between organisations involved in site work. The participants gave various responses for the number of operatives on site, which ranged from 2 to 300. The number of operatives reflects the complexity of the construction site and the background of the participants; while on site, the size of subcontractor organisations varied. For example, a subcontractor company could have less than five members; this reflected the survey results as most participants from small organisations had a small number of operatives on site. In

construction, a small organisation involved in site works is usually a subcontractor. The size and number of employees for each organisation controls the information they deal with, the technology used, and the channel or method of communication selected to exchange information. In addition, the size of the organisation reflects the experience of the participants as larger companies usually require greater expertise to work within their team.

5.1.4 Information Management Issues Of Survey Sample

Information management at the construction stage is discussed in this section. The survey listed a number of questions related to on-site information sharing and exchange methods. To conduct any work on-site, information about the work should be sufficient. Thus, the more efficient the information on-site, the more project goals the organisation achieves. However, Figure 5.3 shows that more than half of the participants (54%) considered that information was not communicated adequately on site.

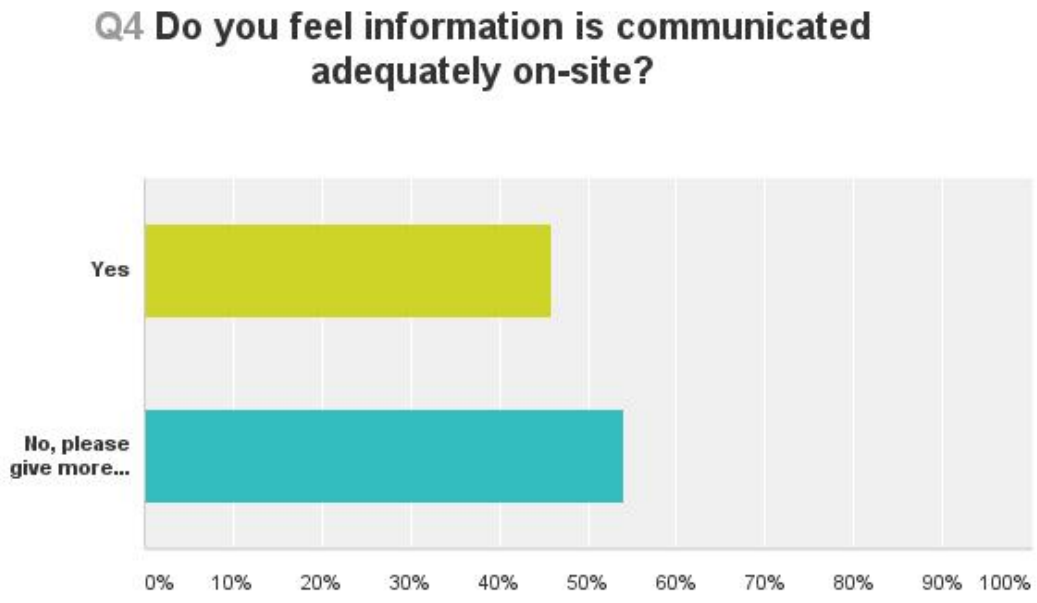


Figure 5-3: Adequacy of information communication on on-site

The comments that participants added to clarify their response could be categorised as follows:

- A lack of control in the production of information and its continuously changing nature; not all required information is issued at the same time. Even when the information has been issued, it is superseded and replaced within days if not hours. This results in frequently out-dated information on-site, even though it is regularly checked.
- The receipt of incomplete information from the main contractor, design team or client generates the need to request further information. This increases misunderstanding

about the information requested or missing from the specifications, and leads to a cycle of information requests.

- The need to wait for approval for many aspects (design, cost, schedule, the method of the application, etc.) that involve a change of drawing, material, and specification.
- Breaking the information chain process by misinterpreting the information when it moves from one party to another. Sometimes the main contractor could fail to use their own internal lines of communication to ensure that correct personnel are communicating, sequencing and programming the works back to the sub-contractor. Also, they could fail to report delays on-site, which reflects the wrong schedule and can waste time and cost.
- Perpetuating a discrepancy in information between the design and construction teams. This means that sometimes the design team does not consider the method of application, which leads to a change in the design, a rework or the need to put the project on hold until the information update is complete.
- The complex nature of construction projects means that many organisations work together on the same site at the same time; different parties (subcontractors) can create silos, which limits collaboration and teamwork on a common set of information. Subcontractors may not access the same platform to communicate; furthermore, not all subcontractors will have a computer on-site to access information, which means they conduct most of their communication over the telephone and as such, miss other channels of communication that would provide the necessary information to get the job done.
- When many organisations work on the same project, information is not obtained from a single authorised point.
- Mismanagement and a lack of coordination arises as many different backgrounds and skills are at work on site, which leads to poor communication. Additionally, having many different departments on site reduces the communication channel when they are not in touch with each other. Thus, out-dated information is sometimes received. Often the site department in the same organisation does not keep the other departments ‘in the loop’; for example, when a contract management team does not update the design team.
- A lack of experience and knowledge amongst the project management team can mean a lack of knowledge about what has to be reported and what does not. Moreover, a delay in communicating incidents can lead to insufficient information.

Construction work is changeable and highly sensitive, as it does not have a clear manufacturing process like other industries. Information needs to be updated and approved on time; when information flows are affected, more detail is needed. Figure 5.4 illustrates the range of reasons for requesting more information. The most common reason is that the information given is unclear (comprising 58.82% of the replies). Meanwhile, 55.88% of participants indicated that such requests meant that information was missing, and 52.94% said that it had not been updated. The other reasons were: unresolved issues, duplicated information, or too much information. According to the literature review, the issue with information is how to control, manage, share and read it, or how to communicate it in a clear and understandable way in order for it to be readable by the receiver of the message.

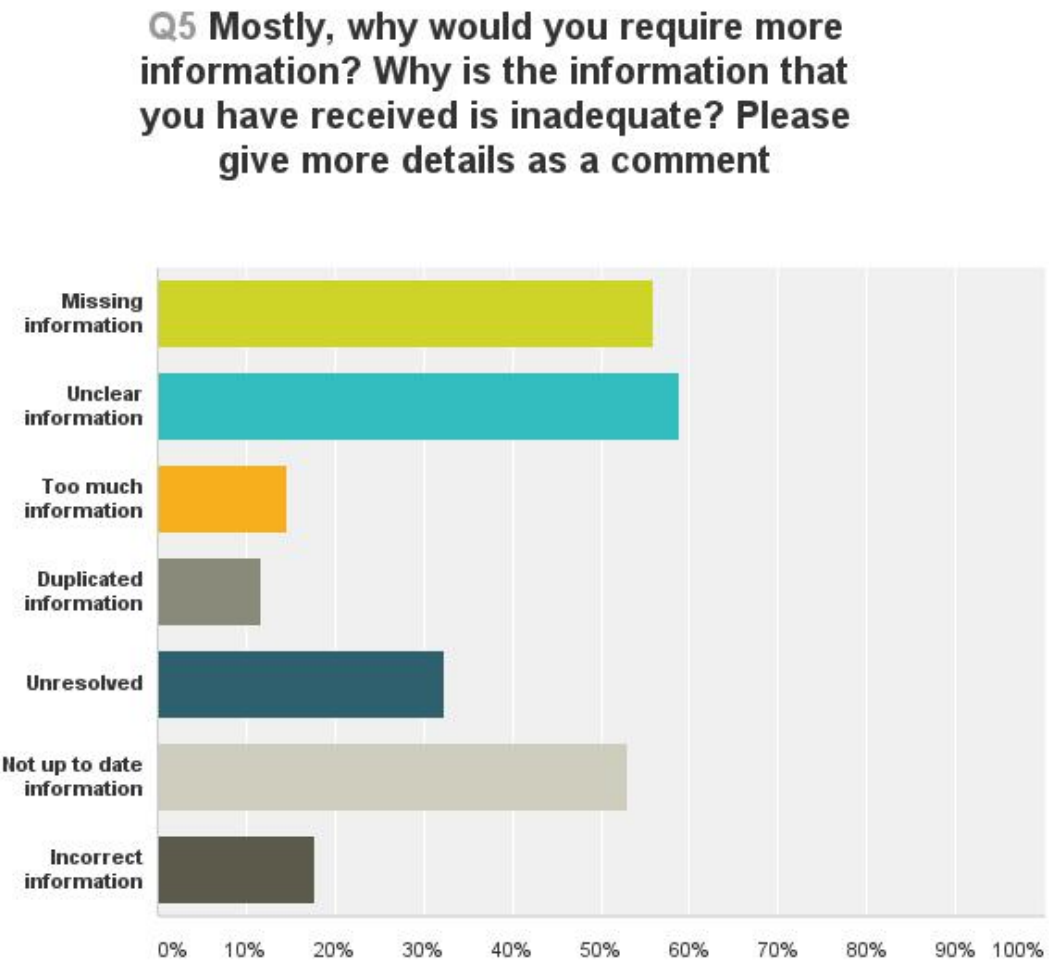


Figure 5-4: Reasons to request further information

Some participants mentioned reasons other than those detailed in Figure 5-5. For example, this included: the quantity of the information processing had increased; the quality and value of the information provided had diminished; and the total knowledge transfer had decreased.

Moreover, responses indicated a lower quality of craft worker skills and knowledge, which was coupled with the poorer quality information and resulted in a lower value product. Some of the reasons to request information were:

- Requesting changes, which could be one of the main reasons for information requests. This subsequently meant chasing other parties who were involved in this change to send the required information for processing and approval.
- Communication mainly depends on the knowledge of the communicator; there is often no consideration of who needs what level of information at any given time. As a result, in order to 'cover all' situations, there are cases where all information is given to everyone irrespective of whether they need it. Conversely, information can also be unclear or missing which sometimes arises intentionally or through genuine ignorance.
- The use of paper-based drawings and documents on-site reduces accessibility to the required information. This increases the risk of miscommunication and wastes more time in retrieving correct information.
- The overuse of email is one of the reasons for unclear information. This could be because of the way that emails are written or the confusing amount of information received. Some participants mentioned that they do not have enough time to go through the large amount of emails received daily.

Communicating the right amount of information is important to finish the job efficiently without creating a clash with other tasks. Figure 5-5 shows that more than 70% of the replies indicated that, when information is disrupted, it results in insufficient information to complete the job. This means an incomplete understanding of the associated activities taking place in the same location, which can affect other tasks. The researcher asked whether participants had knowledge of the tasks that other employees simultaneously undertook; only 29.73% participants considered that they had enough information to start their tasks. They considered that they are totally knowledgeable about the works taking place alongside their tasks. According to the responses, most participants considered that, as long as the work was complete, there was no need for a full understanding of all available knowledge.

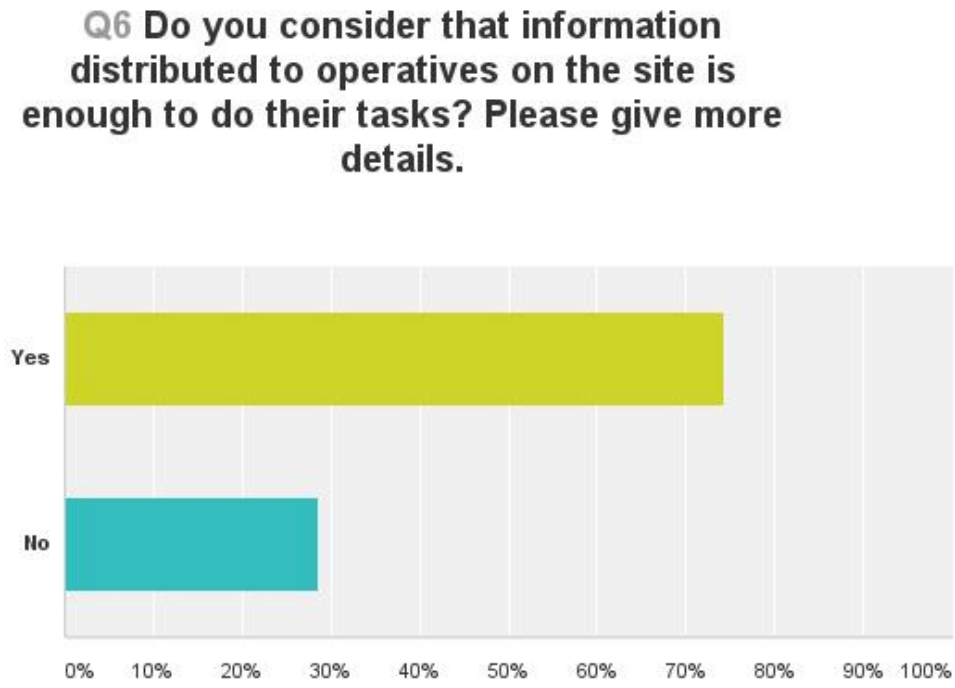


Figure 5-5: Information distributed to operatives on-site

Conducting a daily site coordination meeting between the main contractor and the subcontractors increases the understanding of the tasks due and how they could manage their location on-site. Following this meeting, the subcontractors meet with their supervisors who provide them with the on-site information needed to undertake their tasks. This chain of information delivery could be broken or misinterpreted on one or more level. Reporting back issues that operatives face in their daily work tasks help to improve the quality of the work and avoid the same issues in subsequent tasks.

Thus, the job cannot be completed if the operatives on-site do not collaborate and share information with each other. A daily check on site tasks should take place to ensure that the information used is correct. This task will become more complicated and difficult with the increase in site works that occur daily and the increase in operators on site. Communicating clear information correctly is essential to reduce the need for rework and to reduce wasted material and time. Figure 5-6 shows that 74.29% of participants considered that they received information about the activities that could affect their work. Meanwhile, 25.71% of the responses mentioned that knew about other activities that impacted on their job. The participants explained that they received the collaborative information during the on-site morning meeting, and from this could arrange their daily processes.

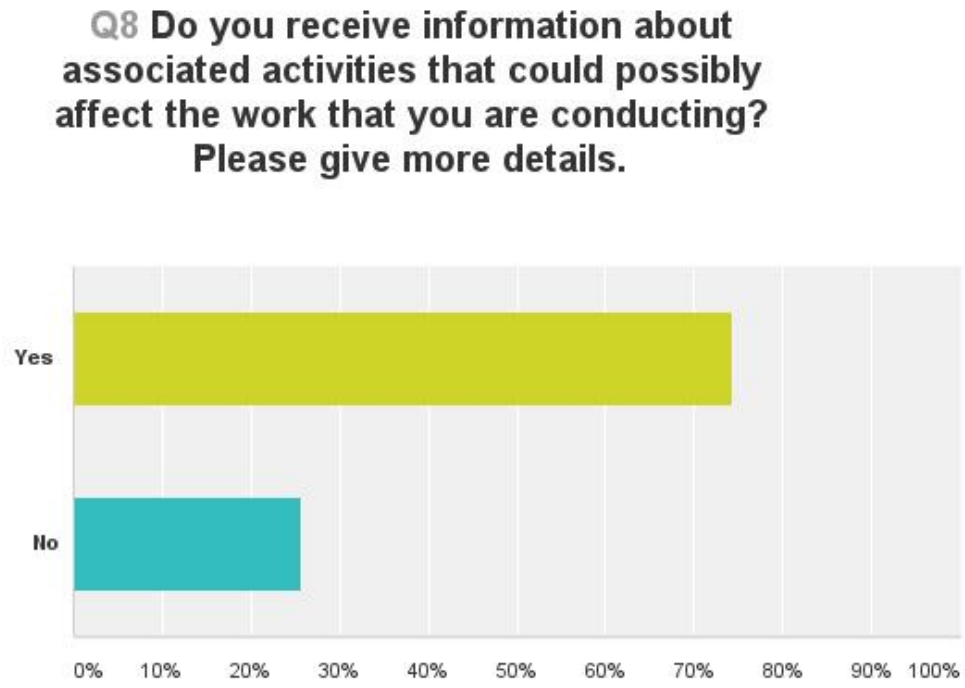


Figure 5-6: Information about other activities

The questionnaire shows that the nature of the information could be provided in many formats. This includes drawings, which are the most important documents on site, and were selected by 63.16% of participants. Reports were selected by 65.79%, verbal information was chosen by 47.37%, which was followed by electronic databases or images, as Figure 5-7 shows. This question highlighted the importance of drawings, reports and verbal communication on site.

Construction projects involve the process of transferring drawings and ideas into solid objects through building projects. For this purpose, up-to-date drawings are vital. Delivering information at the right time is one of the most difficult issues that a construction site faces due to the continuous changes to designs. Any change in the design results in a cycle of communication to request the change, and a wait for the approval and specifications. Daily construction work depends on daily progress, quality, and health and safety reports and forms in order to check progress. The need to document all the stages, information, changes and communicational channels increases the amount of data and forms that need to be completed and transferred daily. Electronic documents are increasingly used to share information including drawing, reports and forms. Nevertheless, although the use of technology has increased, paper is still widely used to convey information in construction.

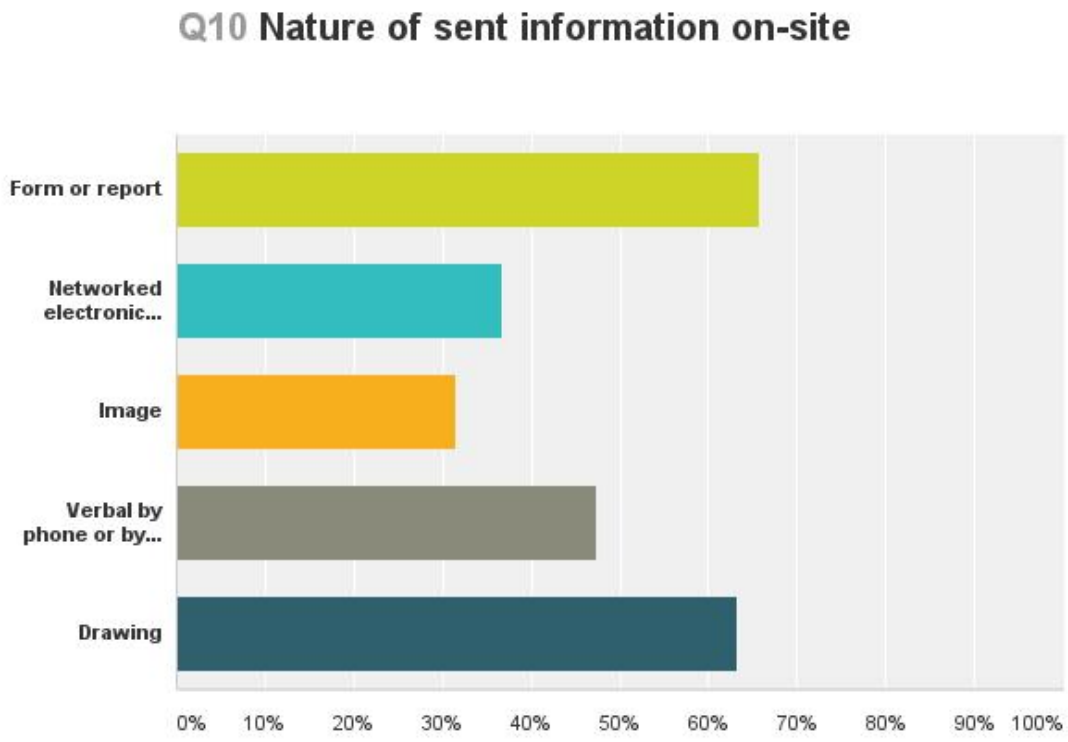


Figure 5-7: The nature of sent information

To collect more information about forms and standards that have been used in construction, the researcher added an open question. This asked participants for details about the forms, reports, and standards they use to communicate and update information. The results of the questions are summarised as follows:

- A Request For Information (RFI) is a formal way to request more information. This is usually sent to the contractor or the client's consultant team. Mostly, it will be used to ask for clarification of information.
- A Confirmation of Verbal Instruction (CVI) is a form to document the verbal instructions that take place on-site during a meeting, a site visit or in an emergency situation. These forms are used as evidence of prior oral confirmation/s.
- An Information Release Schedule (IRS) gives dates for the release of information. It indicates the periods of procurement and the duration of the design approval procedures. It is helpful in demonstrating that the information release dates are credible and realistic.
- An Architect's Instruction (AI) or a Contract Administrator's Instructions (CAI) is usually given to the contractor, as empowered by the contract.
- According to the responses collected by the researcher, owners use ISO 15926. It is a standard designed to integrate, exchange, and share data between computer systems for

life-cycle information. It is a bridging the gap between systems and used by project stakeholders.

- An Inspection and Test Plan (ITP) is a document to describe how, when and who will be tested on site. The main reason for its use is to plan and document the procedure that needs to be followed to provide quality control. This is why it is sometimes called the Quality Control Plan (QCP).
- A Site-Specific Health and Safety Plan (SSSP) is a guide for projects to assist the contractor and all subcontractors working on the project to ensure best management practices are applied. It is an agreement between parties who work on site to control how health and safety will be managed.
- The Construction Industry Scheme (CIS) is a guide for contractors and subcontractors. It outlines the rules for how payments to subcontractors must be handled by the contractor in the construction industry.
- Company Standard Forms are developed by companies for internal use to report on their projects. Daily, weekly and monthly reports are used to gather quantitative information for these forms. This enables the tracking and understanding of progress at certain dates, and allows for a comparison between the actual and planned project progress. It provides a general sense of the productivity of a project.
- Delivery notes are documents that are used to certify the delivery of material to the site. These include detailed information about the delivery as physical evidence.
- A Quality Management System (QMS) is an approach to direct, control and coordinate the quality by identifying the risks for organisations and by providing ways to mitigate them.

These forms help to organise the information transferred and enable progress and quality checks on the project. To elicit more detail about the means of communication used, the researcher posed a question with a number of options; this included verbal and nonverbal methods, and the use of technological and traditional methods. The findings demonstrated that emails were most used, as indicated by 86.49% of the responses. Even though there are many types of technology, emails are still the most commonly used electronic method to communicate. However, participants also commented that emails are received in huge quantities. Some are directly related to the receiver of the email, whilst others are sent to a group to reduce the risk of missing someone. A document control system was the next most commonly used method with 64.86% of the total replies. Participants confirmed that they

mostly use it for design sharing and design specifications. Phone calls were the next most common at 54.05% and printed text received 37.84% of the responses. Meanwhile, mobile Apps were least commonly used amongst the sample at 13.51%. This question showed that paper-based methods are still regularly used in construction, which contradicts the assumption that such methods are becoming marginalised due to the advent of technology. The difference in methods depends on the organisation's size and available tools. Figure 5-8 illustrates this selection.

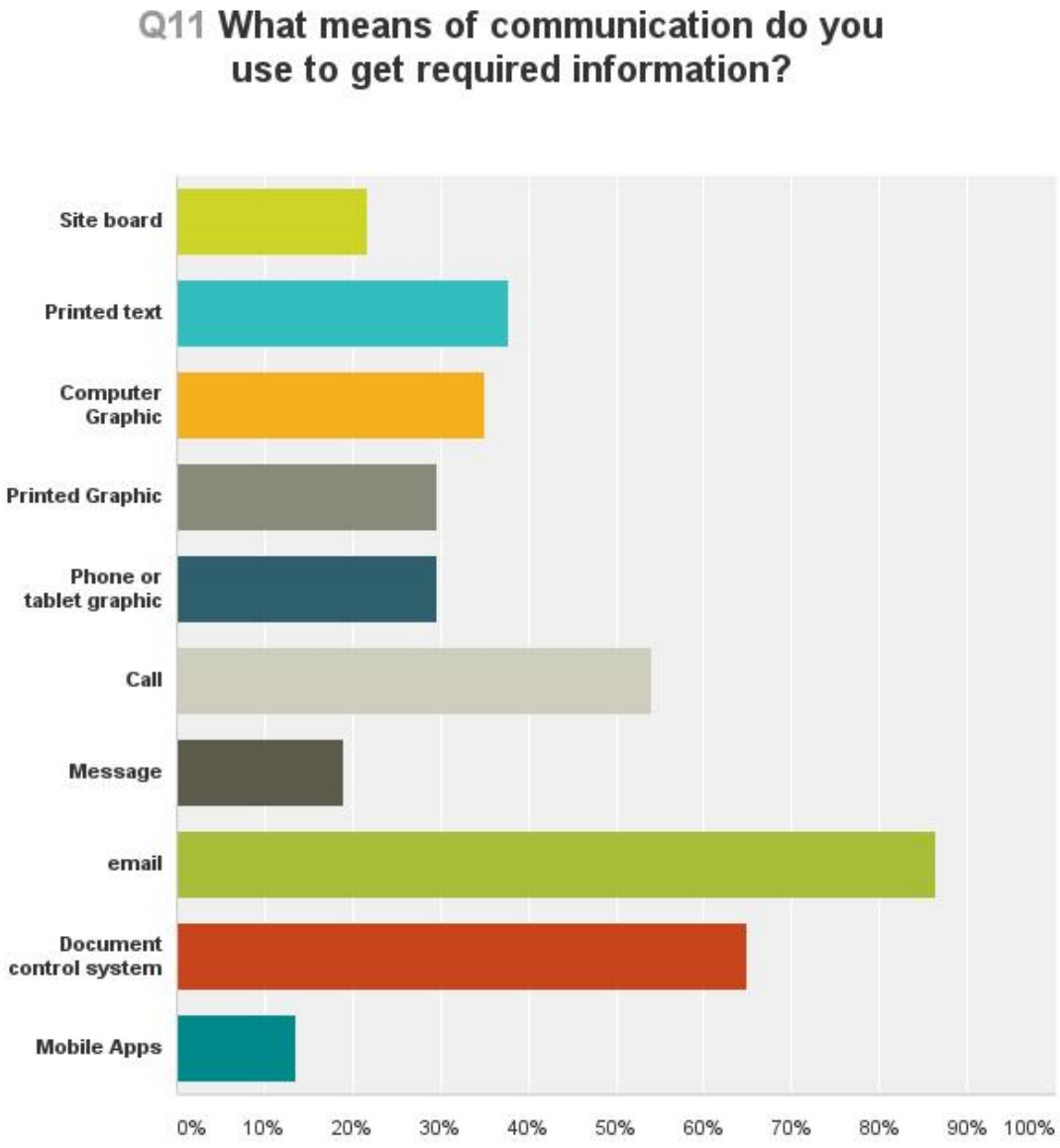


Figure 5-8: Tools used to communicate

5.1.5 The relation between site information and communication method

This survey investigated respondents' perceptions of the preferred methods to deliver different information. This group of questions asked about the receipt of information on site, which includes the information format, and the method used with each format. In addition, participants were asked about the ways in which frequent changes were updated on-site. The researcher listed a number of options and types of information. From the survey, it was clear that emails, meetings and hard copy documents are the dominant approaches used to communicate information. The greatest number of responses indicated that design information was most commonly communicated. While it was noticeable that the use of traditional ways of communicating are still used amongst the sample, the result shows that the use of mobile technology is rarely considered as the main means of communicating. Instead, it is mostly used for health and safety inspections and for snagging. A significant number of responses selected phone calls; however, the information exchanged by phone still needs to be documented. Table 5-1 and Figure 5-9 illustrate the options that were most selected. They show that emails are one of the most popular ways to communicate on site. Meanwhile, an actual meeting was most commonly used according to 79% of the replies. Some participants added that informal meetings or discussions have been used as a way to exchange information and make decisions on site.

Communication and exchanging information on construction site

How would you be informed of the significant changes on the site?								
Answer Options	Task Change	Environment	Scope of work	Health and Safety issues	Work Patterns	Design change	Project plan	Response Count
Written text	31	20	28	20	5	43	23	61
Arranged meeting	28	20	46	48	28	51	48	79
Video conferencing	15	8	18	15	8	13	15	36
Hard copy documents	33	20	35	33	23	46	48	66
Computer graphic	10	5	10	8	5	31	20	46
Printed graphic	5	5	18	8	5	26	21	36
Mobile/ tablet graphic	10	18	10	18	8	10	10	25
Phone calls	31	15	18	28	15	13	13	59
Internal document control system	20	13	35	25	18	30	28	48
External document control system	20	18	23	20	15	33	26	51
Email	48	46	43	56	43	58	51	71
Message	8	5	5	10	8	8	8	18
Voice mail	12	3	5	7	5	5	5	15

Mobile Apps	5	5	5	12	5	5	5	12
Other (please specify)								5
							answered question	94
							skipped question	3

Table 5-1 Information communication and exchange on construction site

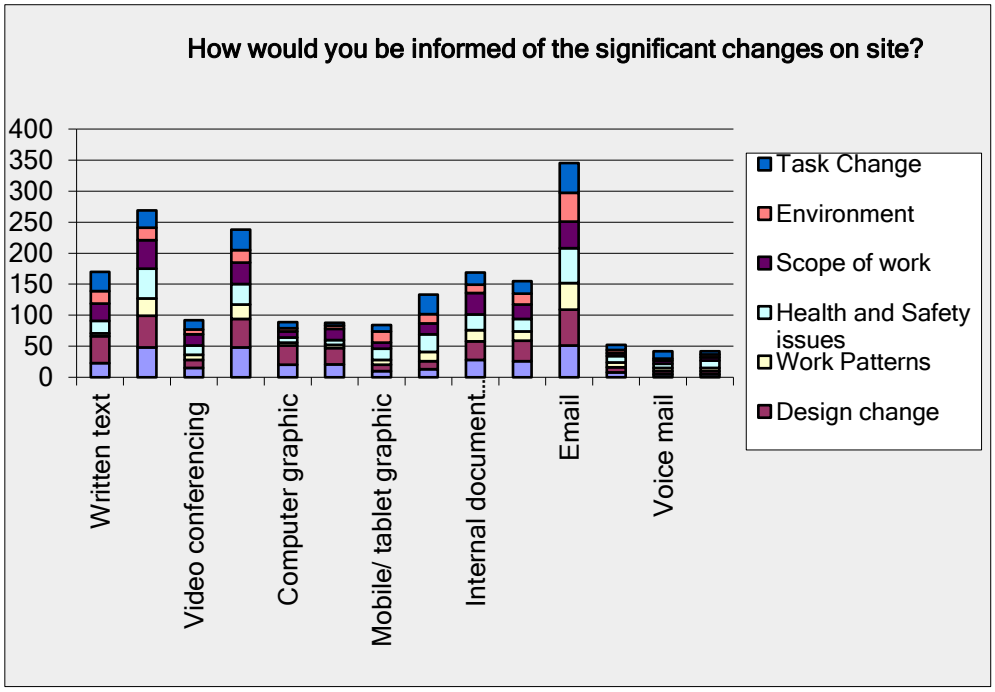


Figure 5-9 Sources of received information on site and the way to deliver it

The method used to exchange site information could be affected by the communicators themselves; each team member has a preferred method to deliver information, although all site operatives agreed that emails are the most commonly used approach. Thus, there is still a preferable and accessible approach to use according to the role of the communicator. For example, the project manager uses all communication channels to achieve the goal of the project and to deliver the information to individual/s who need it on-site. They prefer to interact with other participants during a meeting, face-to-face or/and by email. Some respondents added that the size of the organisation, their responsibilities, and the importance of the information directs the communicator as to the appropriate method. In addition, the results showed clearly that the use of technology is still at a low level in the construction industry. Meanwhile, traditional ways to communicate are still popular on site. Table 5-2 and Figure 5-10 show the results in more detail.

Sources of received information on site and the way in which it is delivered										
Answer Options	Supervisor	Client	Consultant	Design Team	Sub-contractor	Engineer	Supplier	Project Manager	Quantity Surveyor	Response Count
Office meeting	36	51	38	54	38	43	20	64	41	82
Calls	38	38	38	41	36	41	31	51	33	64
Printed documents	28	33	30	43	30	33	33	43	25	61
Messages	26	10	3	5	8	8	5	18	13	36
Face to face	36	43	41	41	31	43	23	59	31	69
Email	43	53	51	56	46	66	48	63	56	76
Document control system	21	36	38	38	33	44	28	41	31	59
Cloud	8	8	15	15	5	18	5	18	8	28
Mobile Apps	2	2	5	5	2	5	2	5	5	10
On-line Sharing websites	5	13	13	13	7	15	5	13	5	20
Other (please specify)										2
									answered question	94
									skipped question	3

Table 5-2 Sources of received information on site and the method of delivery

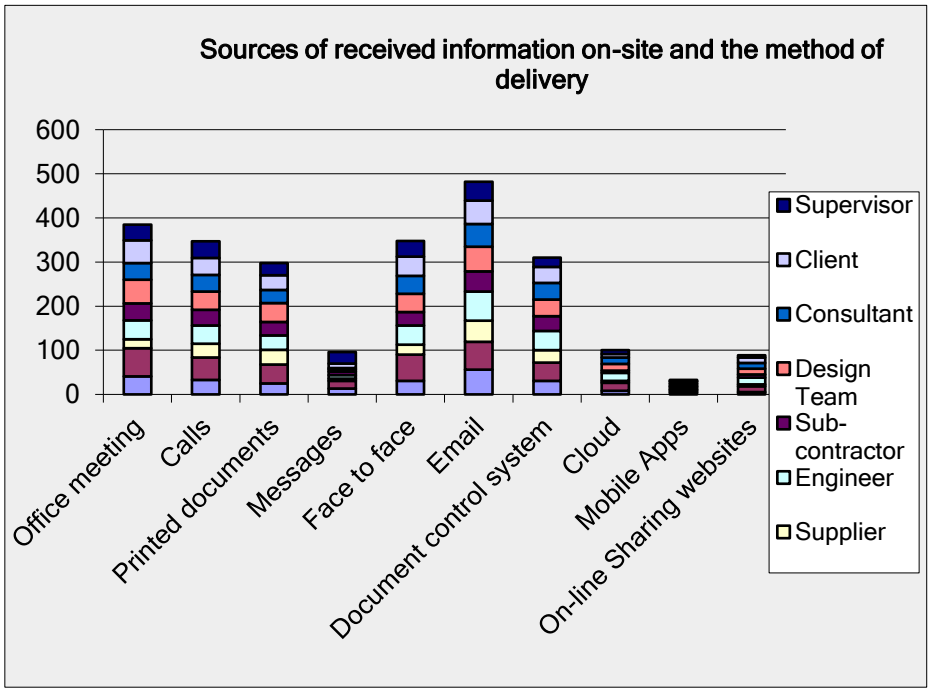


Figure 5-10 Sources of received information on site and the method of delivery

5.1.6 Site office

The construction stage is critical as it represents the final step of a project when design ideas are transformed into a real project; this process demands the communication and exchange of accurate and appropriate information to the on-site office. At this stage, information is important within site offices, which represents the manufacturing environment of the final project. The size of the project office can be controlled by the time, size and cost of the project itself, which reflects on the attainment of the project goal. It exists temporarily to provide information to build the project.

The researcher included a number of questions in this section that aimed to establish an understanding of the needs of the operator or other parties visiting the site office, and to determine the kind of information predominantly requested. At 77.14% of the sample, Figure 5-11 shows that the main reason to visit the site office is to attend a meeting; this reflects the need to communicate face to face and to deliver information to a group whilst also offering the opportunity for discussion and feedback to inform a decision. At 68.57%, the next most common reason is to solve an issue that has arisen on-site. Furthermore, information seeking represents the reason why more than 50% of participants visit the site office. Making decisions on urgent issues that need to be resolved quickly is important in preventing delays. Asking for design details was a frequently cited reason amongst the participants, which includes checking for updates or for tasks that are running in parallel with health and safety checks. The participants commented that they typically use other means of communication to check for information in order to reduce the pressure on the site office. Other methods mentioned were phone calls, emails, radios, being on site, and forms.

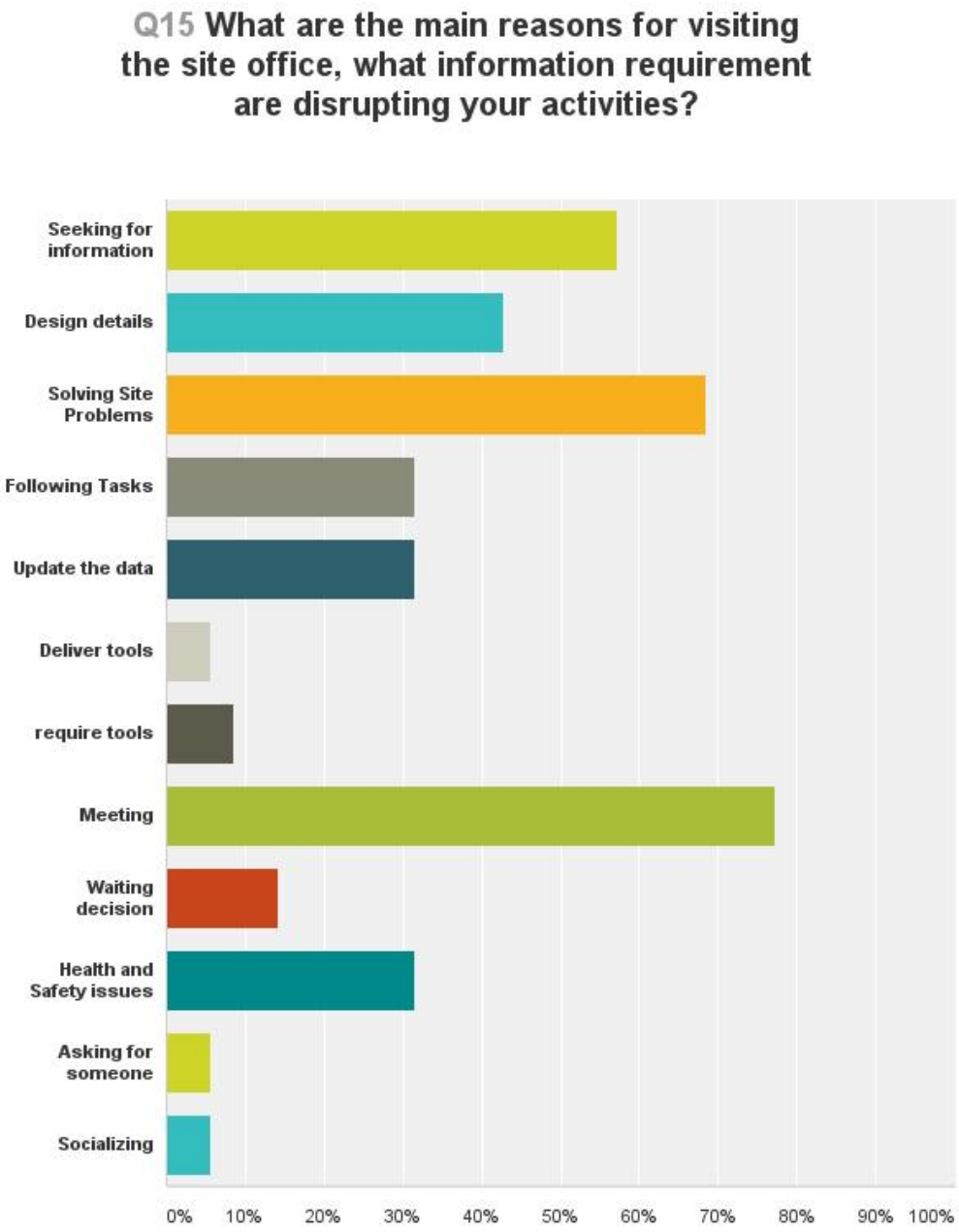


Figure 5-11: Reasons to visit the site office

This questionnaire survey listed a range of information that could be required on-site, as identified from the literature review. For each of those options, participants indicated their level of the requirement by selecting 1 to 5 on a rating scale, where 1 indicated "most likely" and 5 indicated "least likely". Table 5.3 and Figure 5-12 presented an average rate amongst the participants. The Weighted Score (WS) was calculated according to the following equation:

Equation 7- Weighted Score Formula

$$WS = \sum_{n=1}^{5} \frac{nX}{\sum n}$$

Where n = rating score, x = number of responses, and Sum n = total number of valid responses.

Table 5-3 presents the WS for each information statement according to the number of responses for each rank against the total number of participants. According to the researcher, 1 is the most likely, and is thus weighted as 5. The most common reason to visit the site is to check a design with the highest average rating at 3.79.

The communication and exchange of information on a construction site

What kind of information would you visit the site office to check? Please rate from 1 to 5 (1 is the most likely and 5 the least likely)

Answer Options	1	2	3	4	5	N/A	Rating Average	Response Count
Tender	10	6	5	5	18	38	2.65	82
Construction information	23	13	0	15	25	8	2.92	84
Construction management plans	18	16	8	13	21	8	3.00	83
Correspondences	5	8	15	13	13	23	2.66	76
Design	33	21	14	9	6	6	3.79	89
Meeting and liaison	33	8	8	5	25	5	3.24	84
Programs	18	5	22	13	8	13	3.18	79
Daily work instructions	26	3	20	10	15	10	3.20	84
Commercial+ financial	13	13	8	10	20	15	2.82	79
Quality	13	20	8	15	13	15	3.07	84
Procurement	8	14	20	13	13	13	2.95	79
Health and Safety	20	5	15	13	15	13	2.99	82
Temporary works register	15	10	13	13	13	18	3.02	82
Handover and completion	26	10	3	8	25	10	3.05	82
Other (please specify)								1
							answered question	95
							skipped question	2

Table 5-3 The communication and exchange of information on the construction site

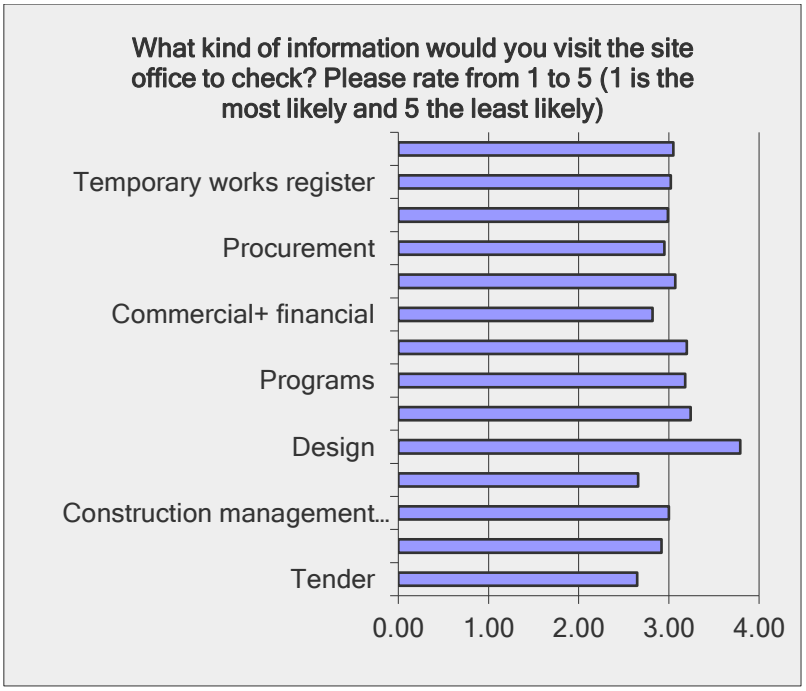


Figure 5-12 Reasons to visit the site office

In theory, within the construction industry time wasting is avoided or minimised. However, to make a decision or effect changes, the time spent waiting for responses could depend on the issue itself. At more than 60% of the responses the average time to request information is one day, as shown in Figure 5-13. The time to make a decision and effect a change differs according to the type of information required, the amount of information that needs to be communicated, the changes that need to be made (if any), the action that needs to be taken, the criticality of the information for the project, and who is responsible in providing that information. Another factor that influences the time taken to provide information is the method of communication used in the request, namely whether it is formal or informal information that is needed. In the case of a request for information, the average time to receive approval is up to two weeks.

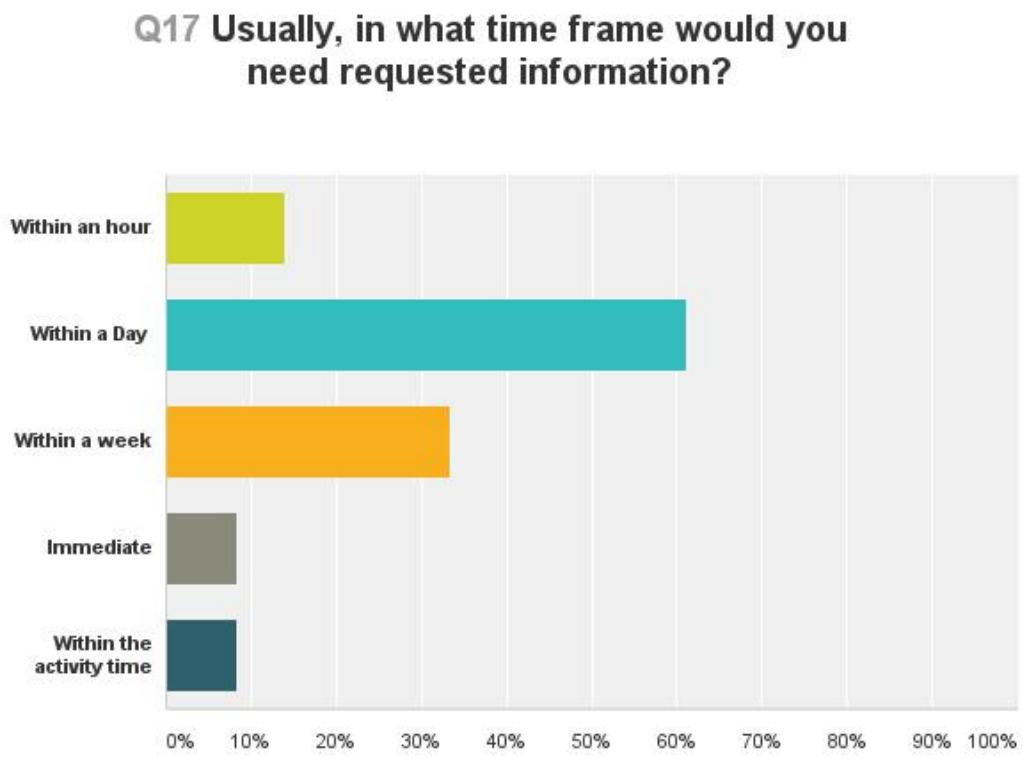


Figure 5-13: Timeframe to provide required information

5.1.7 Communication barriers

The researcher designed this section as a series of open questions. In order to expand the scope of the responses collected from the participants, the data collected from this section is qualitative. The answers have been categorised into four groups, which classed as: information, people, technology and organisation. In the terms of information, many participants considered this a communication barrier when there is no centralised system between the main contractor and sub-contractors. This means having different information management systems between organisations (different formats, flows, codes, and specifications), waiting for information approval, limiting access to required information, and having inaccurate information. Accessibility, accuracy and the quality of the information are the most frequently cited factors that affect on-site communication.

In terms of people, many participants claimed that people are the main barriers to communication. They cited many reasons, such as a lack of information and understanding on the task, different languages, a lack of training, the need for the team to be involved in decision-making, a lack of communication skills, being too busy to communicate on time, a lack of management and coordination skills, differing personalities involved, a lack of experience, and a lack of trust. The construction industry requires a substantial amount of experience and

knowledge to make the process smoother. However, having different generations within the industry can increase the gap between the team members.

In terms of organisation, the participants clarified that their systems, cultures and processes limit their ability to communicate in many ways. This includes; providing specific clarification on the methods of information exchange applied on the contract; focusing on the commercial point; having different policies in each of the organisations that are supposed to work together; the need to have every dialogue documented, either to shift the risk or because of a lack of trust; having different approval systems, and the need to use paper. The presence of many organisations increases the complexity of a project when many participants have different understandings, knowledge, and ideas about a project.

With regard to technology, the replies showed that some of the barriers to communication include: the overuse of technology; a lack of training or understanding of its limitations and capabilities; the overuse of emails; having a fast program; and the cost of technology. 'Box-ticking' is one of the activities that delay the intervention of technology on site, as many employees do not usually understand the concepts of technology. The link between people, information, and technology defines construction and its effective communication methods and tools. Nevertheless, some participants indicated that there were no barriers and they managed to communicate effectively. Moreover, many of the barriers were found to be linked. Therefore, addressing one will help to reduce the impact of others.

5.1.8 Mobile technology

Technology is arguably taking the world and its industries to another level of information exchange. As construction sites have many organisations with different backgrounds, cultures, and levels of education, this makes the adoption of new technology a long process. This survey included a list of information that questioned whether mobile technology could be an option to improve the quality of a project. Participant responses indicated that mobile technology on-site was mainly used to access email, while other options were used less on site. Figure 5-14 shows the use of mobiles on site, and indicated that mobile technology exists to check health and safety issues and to conduct inspection reports, progress reports and check daily diaries.

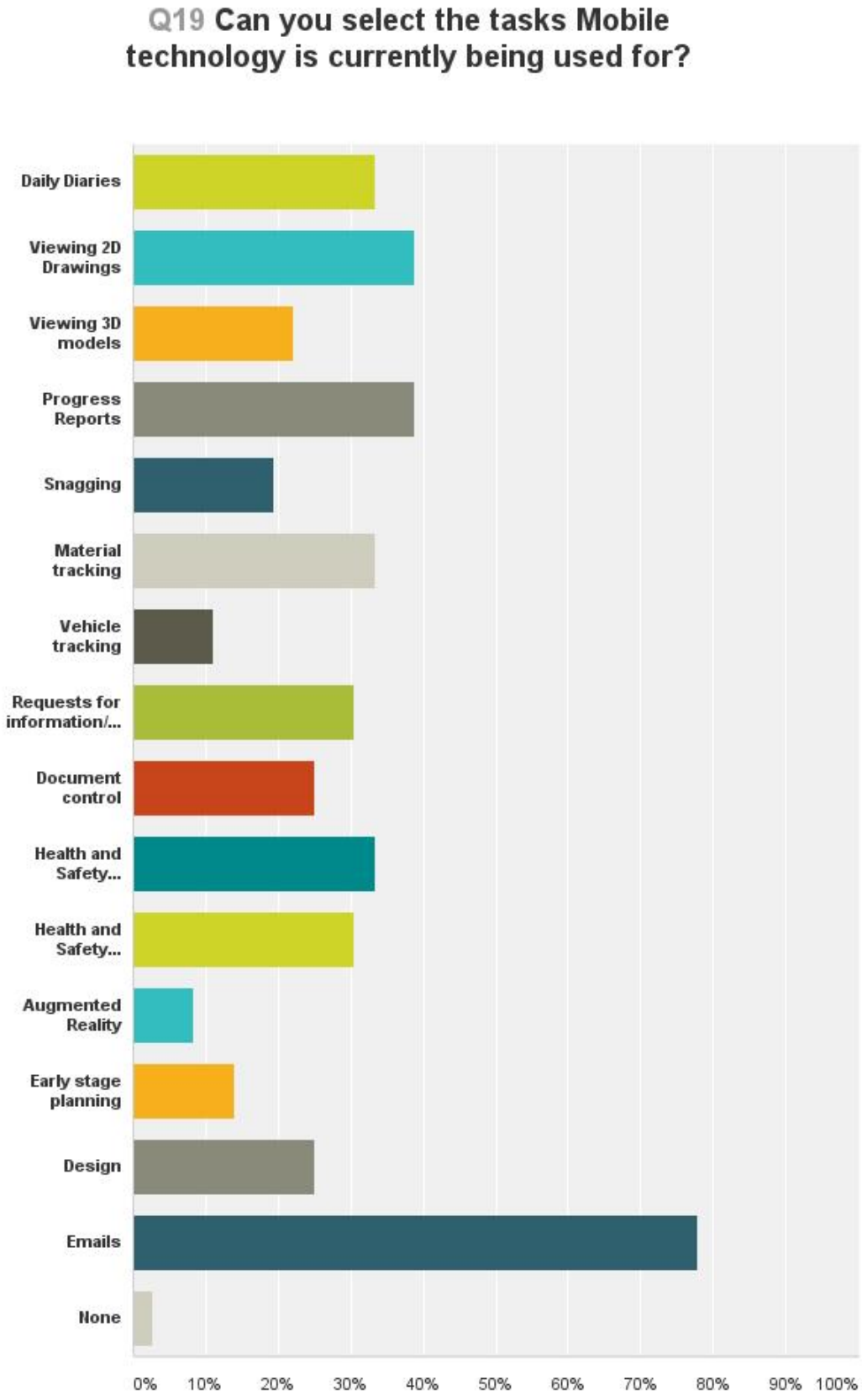


Figure 5-14: The use of mobiles on site

The next section of this questionnaire addressed the factors that could help to improve communication with on-site offices; this focused on the use of mobile technology and gave a number of options with the opportunity to rate their importance from a very large impact to a very small impact. Table 5-4 and Figure 5-15 illustrate the list of areas to develop. Top management support seemed to be the most important factor to improve communication and increase the use of mobile technology on-site. This was followed by an awareness of the benefits, the familiarity of the interface, the perceived ease of use, health and safety issues, continuous support, training, and perceived usefulness. Other options added by participants were: the standardisation of use, having the right devices to implement mobile technology on-site, and having more services through which to collaborate.

The communication and exchange of information on a construction site

Which factors do you think would have the largest impact on any improvements to mobile communication?

Answer Options	very large	moderately large	large	Medium	small	N/A	Rating Average	Response Count
Top management support	46	13	22	0	3	0	4.18	84
Training	25	8	31	0	15	0	3.35	79
Continuous support	23	8	38	5	0	5	3.66	79
Perceived usefulness	15	15	23	13	10	3	3.17	79
Perceived Ease of use	18	27	12	8	3	3	3.74	71
Familiarity of interface	20	25	20	3	3	0	3.82	71
Awareness of the benefits	31	23	15	5	3	0	3.97	77
Health and Safety issues	23	18	15	3	7	3	3.69	69
Other (please specify)								3
							answered question	94
							skipped question	3

Table 5-4 Factors to improve mobile communication

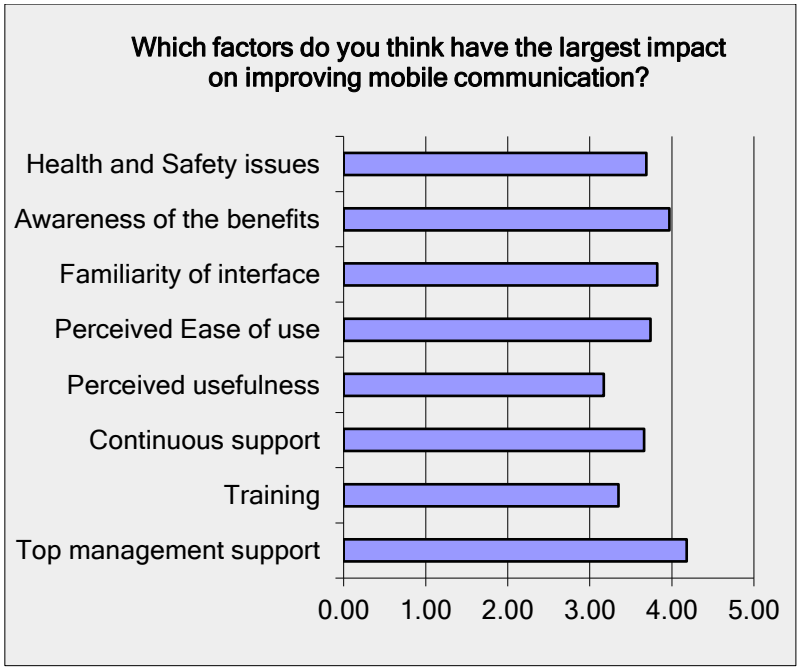


Figure 5-15 Factors to improve mobile communication

5.1.9 Summary of the questionnaire findings

This questionnaire is considered an open survey; the researcher generally analysed the participants' responses as qualitative data. The distribution of participants across differing organisations means these research findings could benefit the exchange and management of information and promote effective communication beyond large organisations. Moreover, the findings generally cover the perspectives of a variety of organisations in terms of size, background, culture and employee experience. However, this research places more focus on the main contractor on-site and their relationship with their subcontractors. Thus, the majority of participants' projects are formed of the main and subcontractor and based in site offices; this increases the reliability of the results. Main contractors are given the responsibility to manage site activities, information flow, health and safety, quality, and cost by minimising waste and time. This highlights the need for this study to determine the challenges in communicating effectively. In order to improve, it is necessary to employ people with the right skills and understanding.

The results are therefore categorised into the following groups:

- The quality of information:
    - Accessible
    - Accurate
    - Secure

    - Up to date
- The production of information:
    - Design information
    - Specifications and instructions
    - The management of information
    - Inspections and reports
    - Commercial information
    - Contract specifications
    - Site information (daily information)
    - The schedule and plan of the project
- Incomplete information:
    - Missing information
    - Unclear information
    - Overloaded information
- Approved information:
    - Incorrect information
    - Out of date information
    - Changing information
    - Misinterpreted information
    - A lack of clarification
- The discrepancy of information:
    - Different versions and sources of information
- The delivery of information:
    - Formal
    - Informal
- The method of information exchange:
    - Site boards
    - Emails
    - Paper-based drawings and documents
    - Phones
    - Meetings
    - Face to face discussions
    - Mobile Apps

Even though most participants thought that they were provided with sufficient information to complete a job, they indicated that they did not have full knowledge of other tasks, and the information they received about such was inadequate. To provide the right amount of information at the right time and ensure that it is accessible to the people who need it most, communication should ensure effectiveness. Further clarification could be requested for many reasons, although this was mostly due to unclear information, which leads to the need for a clear communication flow. This could specify what information to exchange, including to when, whom, and where it should apply. Communication could entail the use of many methods and formats according to need. Selecting the right channel for communication could reduce the need to request more clarification.

Information needs to be communicated among the site team and parties who are involved in on-site works as they are the information communicators and the ones who are in control. People in construction are the presenters of their own companies; they reflect their organisational culture, processes, and management systems.

Aspects that could affect the site team's communication are either organisational or people-based, as follows.

- Organisational issues:
    - Having many organisational management systems
    - Contracts between organisations
    - Complexity of projects and relationships among organisations
    - Project time, size and nature

- People issues:
    - Generation
    - Personality
    - Skills: especially managers' skills
    - Knowledge and experience
    - Continuous training
    - Responsibility of the employees

From the data collected, the researcher found that the use of technology in construction is at a basic level as it is still mostly used to read emails and communicate information. Although the use of a documents control system is considered, according to the survey data it has only been used to share designs and specification documents. However, according to the literature, there are many uses of mobile technology on construction sites, although what a site team uses is still limited within a project.

The aspects that affect technology are;

- The use and need for technology
- Its accessibility and security
- The tools and devices to use
- Training: how to use technology
- The price of technology
- The awareness of technology
- Top management decisions to adopt technology

Effective communication has many barriers, which are: people skills, technology as hardware and software, the organisation as policy, processes and systems, and information management. Figure 5-16 summarises and links the chapter's results. These results can be compared with the observation results, which covered two large main contractor organisations and their site offices. The comparisons of the literature, survey, observation and interview results helps to triangulate and validate the findings, which aims to improve the information flow and ensure effective communication in construction companies.

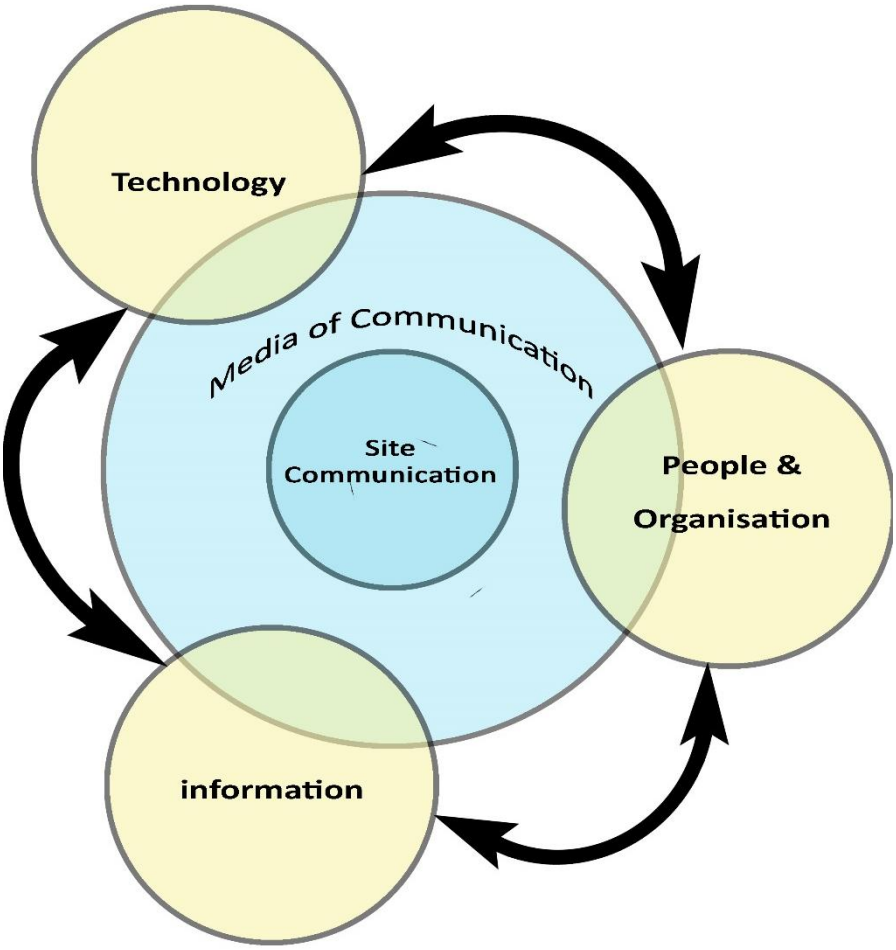


Figure 5-16 Framework

6 Chapter Six: Phase Two – Case Studies

6.1 RESULTS AND DISCUSSIONS ON EXPLORATORY INTERVIEWS AND OBSERVATIONS (PHASE 2)

In this phase, the researcher presented the work conducted at the site offices to understand the problem(s) from an industrial point of view and to determine whether there is a need for a solution(s). It presents and discusses the evidence gathered from the exploratory interviews and observations. It also discusses the findings from the unstructured interview on the current understanding and application of communication methods and information exchanges based on site offices in the UK. The results from the observations on these practices are discussed, which were conducted at two different building sites in the UK. This phase provides empirical evidence on how the current understanding and application of communication, and the delivery of construction projects in the UK align with the advocated principles of technology. The findings presented and discussed in this phase include the current view on construction communication, a method of information exchange, factors that affect communication on site, the technology used and the communication barriers within the on-site offices.

6.1.1 Coding System

The observation and interviews yielded intensive data sets that needed to be carefully coded using a consistent system. Whilst the general coding process has been explained in Chapter Four, this chapter provides more detail about the codes that have been used and the way they have developed and emerged throughout the data analysis process. The intersection shown in Chapter Four confirms that the codes will cover both facts and perceptions. To ensure a clear distinction between the perceptions and facts, the researcher noted phrases, such as ‘I think’, ‘I believe’, and ‘in my opinion’; these phases indicated perceptions rather than facts. Moreover, during the observation the researcher engaged with the interviewees (active interviewing) to confirm whether they were talking about events, which would be documented as facts, or were offering opinions.

6.1.2 Description of the projects observed

The observations were conducted within Manchester in the UK at two main contractor offices. A leading UK construction and infrastructure provider ran site A; the site office for this project was a two-storey exited building to serve a six-storey office block which will eventually accommodate up to 2000 staff within a 145,000 square feet block. The cost was around £1.6

million to implement and maintain the project for 20 years. The implementation was a three-year project plan, which started in 2016 and was expected to finish in 2018. In comparison, an international property developer and construction company, ran site B; they were considerably newer as they only entered the UK market in 2013. The project was a new residential and commercial neighborhood, which was set to comprise 750,000 square feet of commercial and mixed-use development and 2,000 new homes at a total cost of £700 million. Both sites were building projects and within two large main contractor organisations; the researcher considered them two separate cases as one was new to the UK industry and the other was mature and established in the sector. These differences mean they were good cases to compare and gain a greater understanding of communication within on-site offices.

6.2 Case Study: Site A

6.2.1 Analysis, Presentation, and Discussion of the Data

The findings presented and discussed in this section include; the current view of construction site communication and information exchange; the main contractor perceptions on-site; the exchange of information and communication strategy; the tools and technology used; the barriers to both effective communication, and to the use of mobile technology on site. The researcher was on site for an average of two to three days per week over a five-month period. This enabled the following: attendance at meetings with team members; observations of the site situation and noting the issues that arose; observations of informal discussions between the site team, and the conduct of two interviews in the site office with members of the site team. Un-structured interviews took place to support the data collected through observation.

Table 6-1 gives an overview of the distribution of the respondents across the site office. The main focus of this research was the main contractor point of view as they were the controllers on site. However, the researcher also interviewed some of the SC team members in order to gather more detail and understanding of the communication process within the on-site office.

Potential participants	Respondent's Code	Organisation
BIM team member	P01	MC (external)
Scheduler	P02	MC
Design manager	P03	MC

Quality surveyor (contractual and finance SC)	P04	MC
Quality surveyor (contractual and finance client)	P05	MC
Site engineer	P06	MC
Site engineer	P07	MC (agency employee)
Site supervisor	P08	SC
Building services manager	P09	MC (Technical specialist; external)
Senior project manager	P10	MC
Site H&S manager	P11	MC
Delivery organiser at the gate	P12	MC
Senior site manager	P13	SC
Document control	P14	MC
Quality surveyor - trainee	P15	MC
Next generation team member	P16	MC (external)

Table 6-1 The Descriptions and Distribution of Interviewees at Site A

MC= Main contractor, SC= Sub-contractor, external= not based in the site office daily.

6.2.2 Current View of the Construction Site Team and Parties: Site A - Organisational Issues

6.2.2.1 Getting SCs on Board

Main contractors are the parties responsible for completing the project. They provide agreed services to the client for a set of fees and potentially by an agreed deadline. Since this party holds the agreement with the client, they receive all relevant information and designs. The main contractor takes on both the client's duties and their own to manage the site tasks and ensure compliance with health and safety law for all teams (namely their own and/or external teams as subcontractors). Rather than hiring employees themselves for the construction task, the main contractor needs to ensure that sub-contractors complete the job at the lowest possible price. Shifting some tasks to the subcontractor reduces the pressure of managing the changing

numbers of people working on daily tasks and sharing responsibilities with other parties. The role of SCs has been dominant under the MC leadership in construction projects. The Senior Project Manager (P10) in case study A confirmed that:

> *… while the main contractor concentrates efforts towards organisational management to meet the needs of the client, the SC specialises on particular project aspects to meet the needs of the MC.*

As the main contractors undertake the agreement with the client to undertake and complete the job, they are responsible for the build job. However, they pass work packages to sub-contractors as they may have more experience on such tasks than the MC; therefore, sub-contracting this work potentially increases the quality and raises some benefits of collaboration.

> *Because the SC's work impinges on the work of others on site, the planning of the SC work is as important as planning of the MCs own labour and plant'* (P13: Site Project Manager).

The MC solicited for bids from a list of sub-contractors who were mostly recommended as those they had previously worked with. The sub-contractor recommended list was compiled over years of working together on projects. The main contractor's quality surveyor informally calls the SC organisations from the recommended list to check their availability to undertake the job and how much time they would need to price the job. Then, the MC sends the work package information to the SCs by attaching the information to an email, putting it on a CD and posting or sharing it with them using a File Transfer Protocol (FTP) Dropbox App. However, the last option was used by the site QS and was not a regular MC procedure. The main contractor usually gives the sub-contractor up to two weeks to price the job and submit their offer to the quality surveyor for review. The QS decides with the project manager and the rest of MC site team, which SC will be selected to collaborate on the job.

A decision will be taken on the price and referrals**,** which will help the MC to gather sufficient information about their average job size, their volume of work, accuracy, level of trust, reputation, safety records, commitment, punctuality and their ability to collaborate with other teams. P04 said, *"... working with SC that you been worked with before reduce misunderstanding and delays, and increase trust between site team members*." Furthermore, P05 stated that,

> *Building a list of trusted SCs reduces the risk of claims, delays, and extra work and cost. At the same time, it improves relationships among the site team, trust, and communication to do it safely and without risks to health .... We dealt with one of the SCs who was a nightmare for the project in the concept of communication and sharing information.*

6.2.2.1.1 Pre-Contracting at Site A

After the selecting the SC and before signing the contract, informal meetings within the on-site office are used as the method of communication. This helps to build a collaborative environment - especially with SCs they are working with for the first time - and enable discussions on key issues. These issues include: storage, equipment, moving plans, the health and safety plan, agreeing a start date, expectations, understandings, technical issues related to programming, logistics and how physically to build the project. This accords with the project manager's decision as the method to follow; this is a pre-pre-contract meeting, which could last up to 30 minutes. This kind of meeting will mostly not be recorded. P10 indicated that, to "*… have an informal meeting with the new SC help[s] to break the ice and prepare to build a good relationship*." From this, a formal pre-contract meeting will be arranged and recorded in order to generate a signed agreement; this could last up to two hours. The contract formats and regulations follow the JST 2011 Standard of Contracts. P04 explained that,

> *… in [a] pre-contract meeting, [the]project manager, site manager, commercial and QS, design manager and H&S manager will attend to go through the parties, people involved, roles and responsibilities, information that [the] MC needs to provide, such as tools, information flow, skips, material orders, information that [the] SC needs to provide such as progress reports, drawing, requirements, etc. And, if a SC provides a drawing, when it will be ready, how to use 4project, a document control web-based software, to upload it.*

Finally, the contract will be signed and sent by email and post to all parties within the agreement. At this stage, the SC will have access to 4projects and receive a notification from the site information management system of the system the MC operates. This covers requests for task amendments, progress checks, requests, defects and information tracking from the site, following the JST Standard Regulation Contract Requirement.

The coordination and management of SCs during the operational period are essential for the successful completion of a health and safety competence assessment. According to participants, the MC needs to ensure that all SCs are provided with access to the information they need to enable them to carry out tasks safely alongside the following;

- meet information requests promptly;
- check the work permits of labourers;
- provide SCs teams with an induction to give brief information about the risks and communicate health and safety regulations,
- check the environment and quality of workmanship related to the site work;
- conduct a documentation review and issue acceptance prior to the commencement;
- conduct a daily 'breakfast' meeting to arrange daily tasks, areas to work on, delivery, program progress and to ensure communication runs smoothly amongst the projects parties;
- arrange regular meetings to discuss and agree on topic aspects that need collaboration and progress reviews;
- provide supervision, test activities and inspection;
- set up the formats of SC progress, completion tasks reports and records;
- communicate the review and comments to the SC to amend the defects that the MC identifies, namely snags;
- sort out payments after checking and accepting the task completion.

The MC is responsible to the client for the building job, including the parts performed by the subcontractor. This increases the importance of selecting the right SCs. The procurement method used in site A was designed so that the key party responsible for the contract is the main contractor.

6.2.2.2 MC Team Structure.

The main contractor team consists of two parties; firstly, the site employees are based in the site office and deal with the day-to-day activities. They work on one project that could be based in more than one location, and move to another project when the work is done at the current site. At site A, the project was based in one location. Secondly, the project's main office employees do not need to be located in the site office as they deal more with management information, managing SCs and the project work environment in order to control the outcome quality and organise the payments for subcontractors. For case study A, site employees are responsible for the commercial and tender parts of the project and for selecting suitable SCs on site. The main contractor team on site A, at the time of observation comprised: the project manager, a commercial team with two quantity surveyors and one trainee QS; two members dealing with commercial aspects where one addressed client issues, and the other was

responsible for working with the SCs (they focused on the same set of work as the team and collaborated to improve the quality of the work by dividing the tasks and roles). Furthermore, the team also comprised: a scheduler, an H&S manager, an operations team (including two site engineers, one site manager and one trainee site engineer), a design manager, a document controller and logistics team, that included people who work on the site to control deliveries, plants/materials, uploading, storage, site gates, waste and recycling, tidiness and traffic management. As the project was temporary, lasting only three years, the MC employed one of the site engineers and the logistics team for the life of the project. They collaborated with an internal team, who did not have the same options to access the MC facilities, training, information and systems. For example, P07 mentioned that,

> *I am not the MC employee so I have my own email, computer, and company. I got limited access to 4Project, like SCs, and no access to the MC system management, Wi-Fi, or printer, even though I am part of the MC team. To get any information that I need from the system, I either use one of my colleagues' computers as he gave me his password or ask him or any another colleague to print it out for me*.

During this stage, the roles and responsibilities of MC members are defined but issues always arise during construction that need to be addressed by a team. The site team contains not just the main contractor team but also the SC teams, suppliers, specialists, inspectors, architects, and other kinds of visitors who work to deliver the building, reports, and quality of the work through the MC. The MC needs to report the progress to the client and management team. The researcher was able to observe many discussions between the team themselves, as the site office was open plan. Having easy access to the site office to observe anyone who works on site helped to observe the development of the relationship between the MC team members, the MC and SCs and between the SCs themselves

6.2.2.3 Experience of the Team

Experience is important to develop relationships and to improve the trust level at the site project. According to participants, they agreed that the experience and personality of the PM are essential in improving communication, and encouraging the team to hold discussions to gain more understanding of the information. P06 said that, "*I have been on sites when the PM had a close-minded personality; it used to be impossible to discuss any ideas with him as his opinion used to always be right*." Most of the team members mentioned that the personality of the PM helped to improve the relationship between the team, but that it was not as significant as their experience and knowledge. However, some had a different view as they considered

that the role of the manager was to communicate to their team, regardless of whether they were firm or easy going. P11 stated that the, *"PM controls all the project; if he does not communicate with us the job, will not be done*."

Having clear responsibilities, relationships, trust, skills, and experience of the site team creates a new channel of communication that supports collaboration. The experience of team members helped to ease decision-making as they could compare the current situation to previous issues they have dealt with. P13 mentioned that, "*as I got (sic.) a long experience in site management, I know how to sort issues quicker than a new site engineer as I could be dealt with it before or with similar situation."* The MC's organisation policy is to provide its own employees with a set of training during their work time and according to their role. This is available on their intranet network.

6.2.2.4 The roles of the team members

The main role associated with the site project is the *project manager (PM)* who, as leader of the site team, is key to a successful project. They support the team during the project's day-to-day tasks. For example, P10 said,

> *… as a senior project manager, I got involved from the early stages of the project to help the tender estimating team in the tender process when the MC is trying to win the job with technical issues, such as how physically to do the job, my job is to help run the whole scheme from day one though to the end, the hand over to the owner, and then to carry on for a year after the project is done. I deal with everything but obviously I have a team around me who assist.*

The PM roles included, but were not limited to:

- project administration, motivating and managing the site personnel,
- planning day to day activities,
- managing and attending meetings,
- managing a weekly diary,
- managing changes on site,
- taking decisions,
- updating the client with the progress,
- sorting alteration options when there is an issue that needs to be addressed,
- arranging a site visit, communicating with the team and SCs teams,
- getting additional labour,

- helping with design issues,
- supervising the overview of the information flow and tasks, linking the team departments' information,
- interfacing and presenting.

The PM is also expected to have experience of working within a multi-functional management role, and to possess mandatory communication skills.

The *senior site engineer* monitors the structural works, supervises the SCs' progress and labour, conducts health and safety, and quality checks, arranges daily morning meetings to help the SCs communicate and work together, checks that SCs are using the latest design update, checks defect, conducts snagging, daily reports, and inspection tests to check for quality. Furthermore, the SSE updates the site information, checks deliveries, attends meetings and checks the logistics of the site. The senior site manager works with the site engineers to ensure that the project is built using the right information; this includes ensuring the correct drawings and specifications. Moreover, if the job is not completed properly, they take a decision to redo the work or to modify the information accordingly. P11 stated that, *"... we are checking the information flow by selecting a daily sample of labour to ask them if they know about the tasks they are going to do*." Finally, the SSE directs new trainees to the skills they need to achieve in order to attain a higher level of experience and improvement.

Quantity surveyors go through tender process to manage and check that the project is still within the approved budget. They prepare the bill of quantity for the project, select SCs, sort out contract issues, check the progress of the project, address valuing changes, assess claims, negotiate with interested parties, control construction costs through accurate measurements of the work required, apply expert knowledge of the cost of work, labour, materials and the plant required. Moreover, the QS needs an understanding of the implications of design decisions at an early stage to ensure that good value is obtained for the money expended. They are expected to advise clients on ways of procuring the project. P05 confirmed that,

> *... we have to manage the costs of a construction project. Our role is to help to ensure that the construction project is completed within its projected budget, define the materials cost that are needed for the project, prepare tender documents, contracts, bills of quantities. We liaise with the client, project manager, design manager, site manager and other construction parties to get the job done with right information, materials, costs, and progress.*

The *design manager's* role on site is to coordinate the design, which will include both mechanical and electrical (M&E) facets and take into account any commercial requirements.

Therefore, the DM needs to ensure the design fits the budget. The designer needs to check the drawing and clarify this with the site to ensure the design is buildable and includes the required information. Furthermore, drawing approval is one of their responsibilities of the site design manager. The DM could arrange a meeting with the client or design team to discuss design issues and alternative possibilities in the case of design changes or design mistakes. P03 clarified that,

> *… as a site design manager, it should be sure that the designs include the project management requirements, which is how to build the designs, and how the men on the site could fit it. Is it physically possible for them to do it! So, the design manager has to coordinate between the commerce of the project and the actual design team to come up with what the project requires.*

The *scheduler* plays a vital role in the construction project; helping to manage both time and resources to ensure the work is completed on time. The job of a scheduler is to create timetables for the entire project, which include determining the timing of the tasks and when specific materials will be needed. Construction work is often cyclical and delays are normal; thus, a scheduler must ensure that projects are fully staffed when appropriate, and that workers are able to access tools and building materials. If an unanticipated delay arises, the scheduler must re-adjust timetables as much as possible to avoid wasting further time and money. This may be challenging, especially given the external pressures from clients, government restrictions, and the project manager, as P02 clarified. The main team drafting the schedule are based in the main MC offices, and the team on site is responsible for checking the progress with SCs to update the original program.

A *document controller* (DC) is responsible for controlling the numbering, filing, sorting and retrieval of the electronically stored or hard copy documentation produced by technical teams, projects or departments in a timely, accurate and efficient manner. Documentation may be of a confidential or sensitive nature and need to be stored in line with company and industry guidelines. The main document control team is based in the MC main offices as they are responsible for controlling the organisation's documents for all projects. While on site, the DC is in control of selecting who can access these documents, or approve or change them. P014 explained that,

> *… all project drawings and specifications upload on 4 projects; drawings get an update version regularly. I have to check the daily up to date version of the drawing, print it, add it to drawing file and bin the old version*.

The *logistic team* comprises the *gate man* on the main gate; P12 stated that,

> *I got a number of deliveries coming in, so every day I have to get the delivery ticket and sign it. Then, at the end of every day, I have to go to the MC site office and photocopy it and put it in the delivery bag. Then, once a week, someone else comes to the MC site office to get it and type it all in, then, take it back to the main office so the commercial department can sort out paying.*

This slow process leaves room for mistakes to happen as the company may only notice a wrong delivery after a few days. P10 mentioned that,

> *It would be easier to have a scanning system that updates the delivery information immediately to allow the project manager to compare it with the design and the specifications. The method that we used is kind of old school, which keeps using lots of paper.*

6.2.2.5 Site Office

Unlike other site offices and because of the size and location of the project, the MC used a pre-existing building in the project location that was owned by the client who gave permission to use it as a site office. It was a two level building; the ground level was for the SC offices and provided space for their labour, plus a daily meeting area which included boards as a method of communication and information exchange, and a meeting room for site inductions that were provided by the MC at the beginning of site participants' work. It could also be used for SCs to hold their meetings. The daily updated boards included information sharing, such as a delivery board to plan for the week ahead, a three-week 'look ahead' program, hazards, and a map of the project to manage logistical issues on site, such as movement and SC workplaces. Figure 6-1 shows an example of the boards used in daily meetings within the on-site office. Meanwhile, the first level of the building was for the MC team, which included the MC team's decks and a room for site meetings.

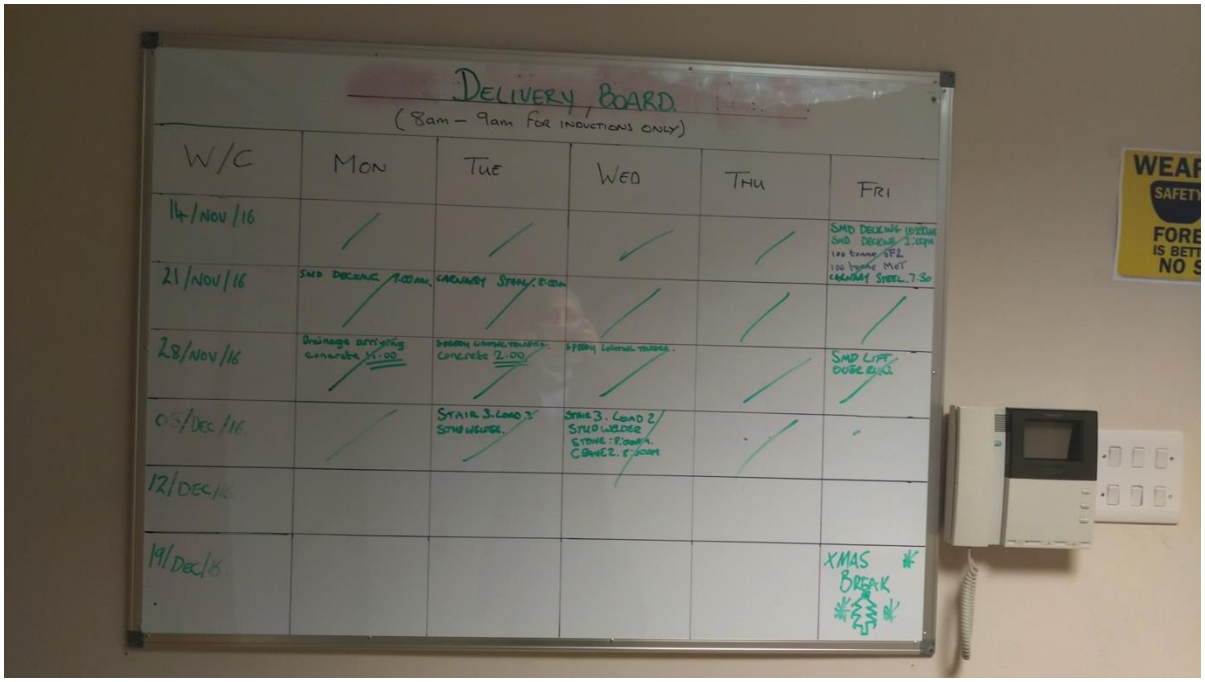


Figure 6-1 An Example of Site Boards.

P07 stated that,

> *… having an open-door policy creates a culture on site to communicate, build a relationship with people on site, ease collaboration between team members as you can ask for information that you need to do your job while you are working and everyone in the office can contribute*.

Similarly, P13 added that, in the "*… open design office we got on site help that anyone could go to anyone for assistance and the willingness of all of them is to help*." Furthermore, P08 clarified that, "*… having open space makes collaboration with other SCs easier as you can go to their deck and ask them for details that needed."* He added that the, *"MC team members are reachable at any time; you just need to go upstairs and speak with them directly about any issue*." In comparison, P11 stated that,

> *… even though having [an] open space office is helping to communicate easier and reduce the distance between the team departments it does limit the personal space for the team members. You have to hear everyone's conversation even those you are not interested in.*

Therefore, having an open door policy generally helps to improve the quality of the work and increase trust and communication among the participants. However, it can also bring some challenges.

6.2.2.6 Other Aspects Related to People and Organisations;

6.2.2.6.1 Generation and Complexity:

The project environment becomes increasingly complex due to the increase of members on site and the organisational employees involved within on-site work. In the construction industry, the structure of team members, specialists and other parties involved in the project also mean that individuals come from different backgrounds, companies, cultures, and generations, which increases the complexity of the project. A different generation may have totally different goals, with diverse methods to manage experience and understanding. Furthermore, they may see project issues differently. Although experience can help an older generation to make a decision quicker, the tools and technology used by the younger generation can help them to act and get results quicker. For example, P11 stated that, *"I do not use the Snagging App; I just cannot see the point of it. I prefer to do it by taking a picture of the defect and attach it to an email then send it to SC to be sorted."* Whilst, in comparison, P06 stated that, "… *using the SnagR application reduced the time of the work as it was done more quickly and an email will be sent automaticity to the involved parties."*

6.2.2.6.2 Time:

At the time of the observation, there were five subcontractors on site. The number of SCs on site increases with a project's progress. This increases the complexity of the project, reduces communication channels between each SC, and increases pressure on the site to complete the tasks within the planned time and without any risk. Furthermore, the amount of information needed to complete the job and the clashes between the SCs who work in the same place will increase. As they come from different backgrounds, with different management structures and processes, considering that the main organisation's management systems differ from the SC can help to manage the site, the information flows and SC issues in an appropriate timeframe.

6.2.2.6.3 Managing the Relationship (Trust) with all SCs:

Relationships require manamentment otherwise the project will fail, and this is particularly important when they come from different backgrounds with different organisational structures and systems. Furthermore, they communicate and share information differently, as P11 explained,

> … *sometimes selecting an appropriate way to communicate to an SC depends strongly on the SC system as some of the SCs have a very structural system when they document all details in a formal latter which leads to having a formal relationship, increased*

decision making time, reduced trust as that forces the MC to use the same method of documentation in case of any conflict could take place.

The size of the SC's organisation affects the way they communicate, as they have to follow the same process as their companies. During the observation, the researcher visited the SC's workspace and noted that some SCs do not have a computer at the site office to access the latest information updates on 4projects. This meant that they visited the MC office many times to check they were working with the right version of the information. P06 mentioned that,

> *… having accessible information available for every SC does not mean that they will use the last update to construct the project; some of SC's organisations have two or three employees on the site to do the job. They do not have even a computer to access the information*.

Construction projects are known as a complex environment; for example, P10 explained that the,

> *… construction industry is a complicated industry compared to other industry, while you can improve the quality of new products of other industries by doing the same product many times, in construction projects, it is difficult and complicated to achieve*.

The aspects that reflected the complexity of on-site communication are various; the team added that having a social event for the site team can help to improve the relationship between parties.

6.2.2.6.4 The Condition of the Project Site:

The location, site boundaries, weather, size of the project and parties, expectations, and the surrounding environment next to the project affects the condition of the project site. P11 stated that, "*… the complexity of the work increases through the project process as the number of SCs and information that needs to be dealt with increases. Time will be more critical at that stage."*

6.2.2.6.5 Contractual Issues:

Contracts are legal documents that control roles and responsibilities, relationships, tasks, communication methods, reports and inspections, and the timing of the project. As noted in the literature, even though it is important to control relationships, it increases the need for formal communication and a paper-based method of communication. P04 confirmed, "*… when [the] SC sends (paper-based) post to deliver information, the contractual method will be used, and we have to reply using same way, according to contract regulations*."

6.2.2.6.6 Operational and Technological Issues:

The operational and technological issues include the number of parties involved, not having a continuous information flow, the accessibility of the information, a lack of knowledge on how to use technology, the size and differing understandings of the task, health and safety issues, the logistics of the site, feedback, and the checking of reports and progress. P09 stated that,

> *… as a supervisor, it is my responsibility to check that my team are using the H&S tools and they got the right information. We follow a system of warnings to encourage our people to follow the site roles. [The] MC helps by providing the facility needed to be on site and provides a suggestion board that allows people on site to write their suggestions and issues*.

6.2.2.6.7 Top Management Support of MC:

As the MC is a large organisation, the decision to change methods, processes, policies or technologies is rarely influenced at the site level team. For example, P01 said,

> *… a year ago, using the phone on site was banned by the head management office for health and safety reasons. Even though many site managers across the country totally disagreed with that discussion, they had to follow the new policy … As we are starting BIM adoption within our projects, the decision to not use mobile phones came at the wrong time*.

Thus, it is important to include the site team in decisions that could directly reflect their work quality.

6.2.3 Information Management:

In the construction stage, the amount of information is enormous; it should be delivered to the participants who need it on time. Information on site needs to be accessible, accurate, up to date, approved, documented, communicative, understandable and secure. Information could be exchanged through formal or informal methods. To manage site information, the MC organisation has many systems in use on site in order to exchange and communicate information. The system categories used on site for information could be defined in various ways. Participants describe it according to different categories. Information related to team member's roles are divided into: management information (reports, approval, health and safety, execution plan, programming, design, environmental); design information (design, specification, approval); and operational information (day to day information, logistics, site inspection, H&S, Requested information; progress). This also encompasses contractual information (contract, clarification, tender document, quality check, completion report, payment issues, progress measurement, deliveries) and requested information (information that is needed on site that could relate to any of the previous categories. Moreover, information related to the communication exchange channel can be formal or informal, whilst information

related to the state of information could be up-dated, requested and approved. In addition, information related to communication media could be verbal, non-verbal, or electronic, and information related to the format types could be considered to be communication media. Moreover, information management refers to paper-based material (which includes letters, contracts, drawings, meetings minutes, delivery tickets, progress reports and H&S inspections), boards or signs (meeting boards, H&S signs and meeting schedules), voice (radio, calls, e-conferences), or electronically-based information (such as drawings, PDFs, emails, reports, project programs, snagging, instant messages, and internal websites). As all the participants indicated the same information with different descriptions, the researchers divided the information (as indicated in the following sub-sections) using literature as the background.

6.2.3.1 Distributed Information:

This includes all types of information shared among the teams, namely: contracts, design, instructions, specifications, meeting minutes, daily processes, delivery tickets, reports, and other information needed to complete the job. This information has already been approved before dissemination to other participants. Site A's information distribution system is identified as the sharing of files on a document control system (4Projects), or by email. On-site means the use of printed documents/drawings as mobiles are not allowed; instead, paper-based drawings are used in meetings to measure progress, which are then added to the file.

6.2.3.2 Requested Information (Request for Information (RFI)):

When the information needed is incomplete, missing, unclear, wrong or changed, more information is requested. There are two methods to request information depending on who is making the request. When the MC requests information they use their Site Information Management System (SIMS) to generate a form to send to the parties involved. Conversely, when the information is required from the MC, other parties could send an email to explain what information they want or use the open-door policy to ask directly face-to-face. The delivery of the requested information could take up to two weeks. To control the time of the requested information, the MC uses the Information Request Schedule (IRS), which is an Excel document saved on the shared point server and includes details about the information requested.

6.2.3.2.1 Information Required Schedule (IRS):

The IRS will typically be prepared prior to the work starting on site, and using the start dates indicated on the master programme for guidance. The schedule will continue to be updated

during the course of the contract when new information requirements are added as necessary. The purpose of the schedule is to prioritise the importance of the information required to progress the works in accordance with the master programme and to ensure it is received in a timely manner. As the information is received, the schedule will be updated. As and when new information requirements are added, the schedule will be re-issued; it will also be appended to the contractor's report and submitted during site progress meetings. However, it should be possible to determine the 'status' (namely, whether a response has been received and where the details can be found) of all queries if response details are recorded in the 'Note' section. Although this may take a few minutes to complete, it would save time in the future. Main points of the IRS are that;

1. Every project must have an IRS that should be based on the master programme (schedule) for the project.
2. The IRS is an essential management tool and should be as detailed as possible.
3. A project cannot be effectively managed without an IRS and wherever possible the content should be agreed with the design consultants.
4. The IRS is key to the effective procurement of subcontractors and materials and is essential to deliver the project on time.
5. The IRS should be completed right at the outset of the project – preferably before commencing on site and reviewed weekly thereafter.
6. The IRS should be updated and appended to every Contractors Report, tabled at the site meetings and reviewed accordingly.
7. The information dates are required – this must include the date required to ensure the works can commence and proceed as planned. This date must take into account:
    - The commencement date of the on site work
    - The procurement period
    - The approval period
    - The notice to start the on site period
    - The period for manufacture

The IRS uses the following key categories (Figure 6-2), to update the information.

KEY	
	Dates amended to suit CAT B Procurement
	Complete
	On-going
	Over due
	Due in the next 4 weeks
	Not due

Figure 6-2 Key Categories for the IRS

P02, P03, P05 P09 and P10 mentioned that using this approach enabled improvements in tracking the information, making it quicker and easier to access. P02 confirmed that, *"... it is a useful document for any future conflict that could happen."*

6.2.3.3 Approved Information:

Once the submittal and RFI processes are complete, and the submittals have been prepared, they are sent through the approvals process. Whenever the information has been changed, specific design information needs to be checked for approval before distribution. The approval for design information is one of the site design manager's responsibilities. The supplier uploads the design on 4Project, when the design team reviews and comments on the information; after this the design manager needs to approve the information. The DM prints and comments on the information; they then scan and re-upload it as an attached file to the original drawing, selecting one of the options accorded to the workflow system (Figure 6-3). In Figure 6-3, A has been approved without comments, B has been approved with comments and C has been rejected. Even though there is an option to directly comment on it, the design manager stated that, "*I prefer to print it out, and comment on it then scan it as it is easier to view than see on the screen of the computer."* When the information is approved, it will be distributed to other parties as the final information for use on site. In most cases, the MC prefers to select option B, which is accepted with comments. This is felt to be a 'safe' option in relation to the risk of future claims or conflicts; thus, they share any responsibilities with other participants.

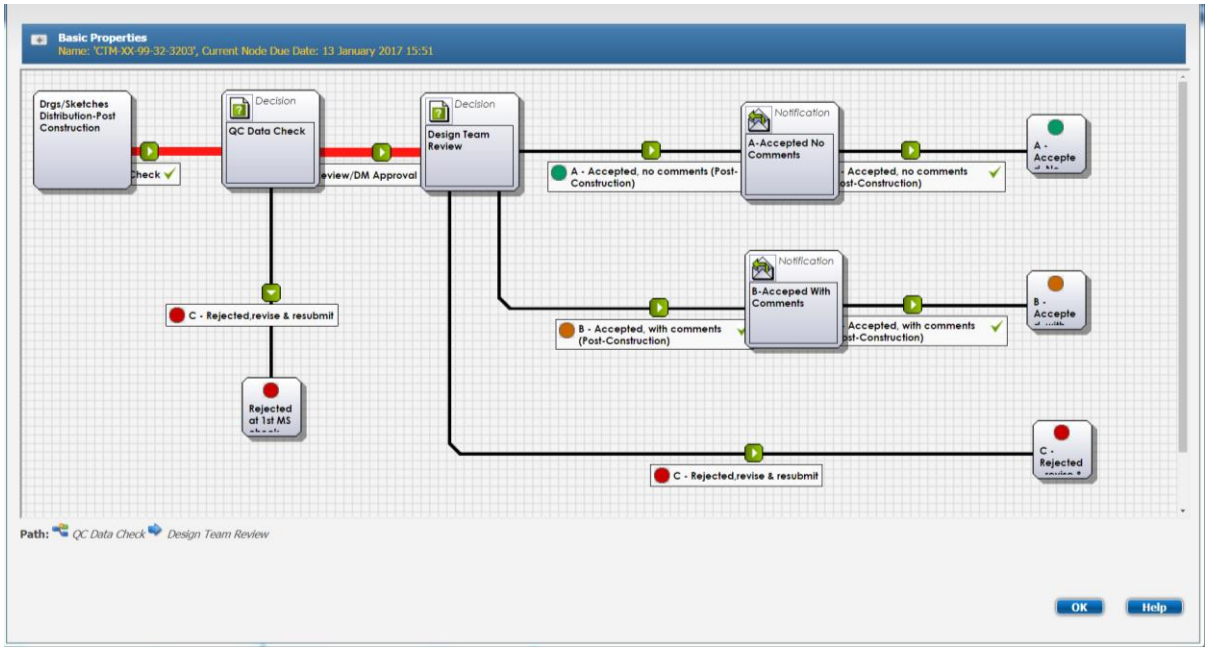


Figure 6-3 Workflow Used on Site A

These three stages are linked, as in Figure 6-4, which shows the information journey during the construction stage. This starts with the request for information and goes through to approval and the task completion done. The overall time to receive the information should be up to two weeks from the request, and up to two weeks for approval; this means the process can take up to one month. The experience of the team member defines which information is dealt with, the speed of the process, whether the information is considered less important, whether it can wait, and when they need to complete it according to its priority.

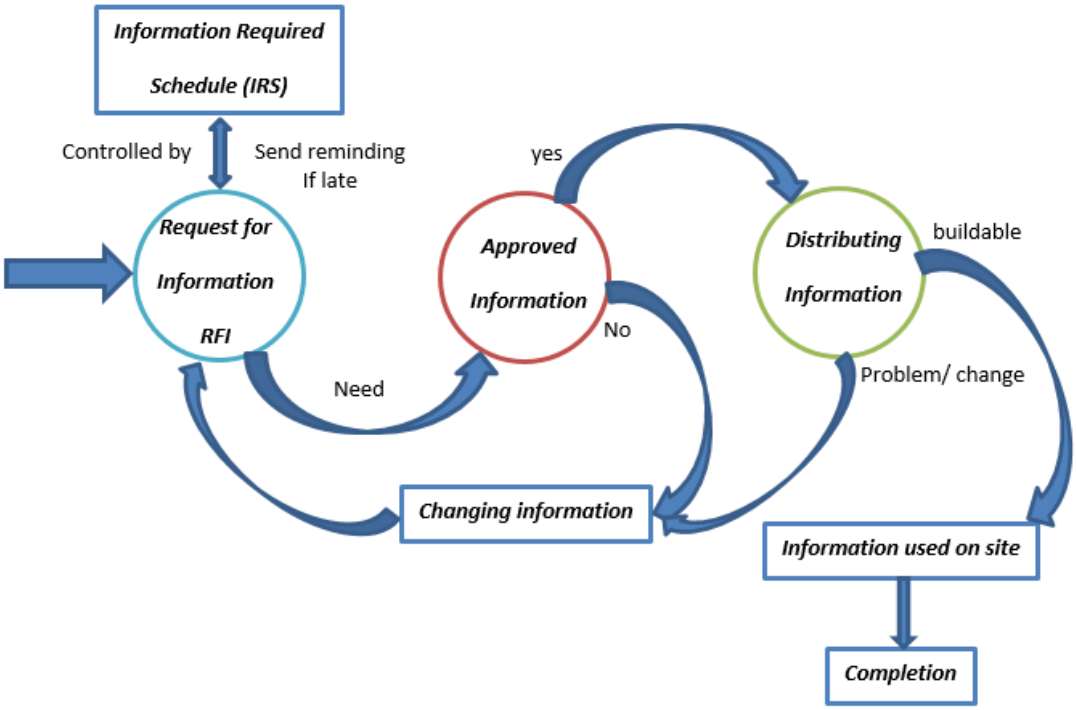


Figure 6-4 Information Cycle on Site

The system of information management the MC uses on site is part of their system to manage the information flow within their organisation. Figure 6-5 shows the management of the information flow used by the MC. The information flows include the management process system that the organisation uses, starting with the pre-contracting phase until the test, commission, and handover stage. The MC team has access to it and greater detail helps them to understand the information flows followed by their company. They describe it as a clear and helpful process.

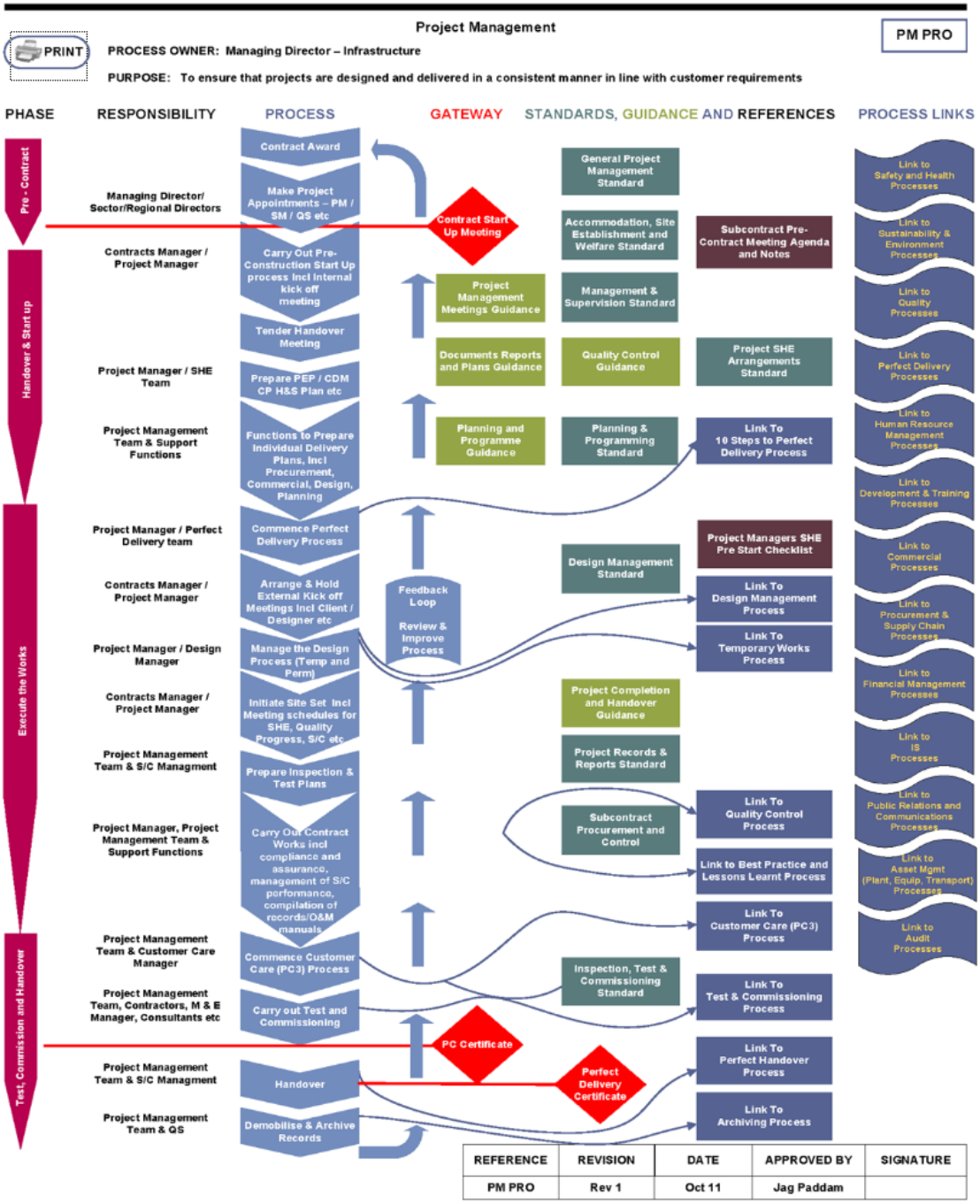


Figure 6-5 Project Management Process (Source: Site A website)

6.2.4 Communication media

In this session the researcher identified and analysed the communication methods that site A use. The researcher categorised them into two groups. Tradition systems refer to the methods that have been used on construction for a while, and technological systems refer to the new methods that construction projects now apply.

6.2.4.1 Traditional systems

6.2.4.1.1 Boards*:*

This method is used during a meeting when they need to keep the results available for everyone to see. The board is used for communication at the morning meeting (the morning meeting is a face-to-face communication as all SCs gather and discuss issues with each other). The information communicated during the meeting and written on thse boards include: the materials delivery plan for the week, the progress plan for three weeks ahead, the work area for each SC on site, hazards and controls, work on site, and observations and feedback, which is an area in which everyone on the project can write their observations on an issue that they face and to which the MC will reply. This was a helpful technique to encourage people to communicate and share their ideas and concerns. Figure 6-6 shows the boards used on site A. These were also used to share H&S information on site. P02, P04, P07, P08 and P11 consider boards an effective way to communicate as they are available for everyone on site; therefore, if someone misses a meeting, they can catch up with the information discussed during the meeting anytime during the day.

Figure 6-6 Boards On-Site Office A

6.2.4.1.2 Radio:

This method is known as two-way radios or walkie-talkies; it is a verbal system to communicate on site between teams. As using a mobile telephone is banned, they use a radio instead of searching for the person they need for the job on site. It is used to control access, movement on site, emergency communication, and delivery notifications. P06, P07, P08, P12, and P13 agreed that they prefer using mobiles to call on site, but as this is banned, the radio at least helps to communicate. They added that they have to conduct telephone calls when an urgent issue arises, but as they need to do this off site, it is easier to make such calls from the site office, as this is in the same location.

6.2.4.1.3 Meeting:

As a face-to-face method, this could be a quick meeting, such as a discussion that could happen on the site to sort an issue. Although it can be informal, there is a need to record whether an important decision has been taken.

- *Daily morning meeting* (verbal meeting with the SCs): the results of these meetings are displayed on the board (informal). P08 and P013 stated that they got most from the information conveyed in the morning meeting, and found it a good opportunity to communicate with other SCs.
- *Pre-construction meeting* (attended by the client, main contractor, subcontractor, consultants, specialist and/or other parties involved). These meetings need to be recorded in meeting minutes which need to be shared amongst all attendees (formal)
- *Construction meeting* (weekly, monthly, or/and on demand): these are conducted to review progress, supplement instructions (such as site instructions), change orders, change directives and RFI's, discuss and resolve issues, communicate the expectations of the contract documents, and exchange technical information. These could be formal or informal, and need to be saved in meeting minutes.
- *Project team meeting* (weekly, monthly or on demand): these meetings review the progress of the work, including the project schedule, progress claims and changes to the contract. These could also be flexible when there is time, and they are mostly informal. The minutes from these meetings need to be saved
- *Main contractor and subcontractor meetings;* these are held weekly in order to coordinate the work and solve problems. For formal meetings, there is a need to record the actions and outcomes and to plan ahead.

- *Project closeout meeting*; these are held at the end of work to discuss procedures and requirements for the completion of the project. This meeting is formal and needs to be documented.

The researcher attended meetings and noted that the team tended to use a folder of paper documents and drawings during the meeting; furthermore, they used an electronic PowerPoint presentation in parallel with paper drawings during a design meeting. They stated that, in most of their meetings they use paper-based documents, as they do not have a space big enough to conduct a presentation during large team meetings. The have a clear agenda, aim, list of rules and timings for meetings. The team considered face-to-face meetings a practical way to communicate information, even though some considered the use of paper an issue that requires addressing.

6.2.4.1.4 Paper-Based*:*

Paper-based documents are still mostly used in the site construction office. This method is used for documents related to contract letters, schedules, drawings to add to a folder and to use on site, measurements for the QS, meetings to comment on reports, H&S checks, progress checks and reports, meeting minutes, and inspections. There were two opinions related to the use of paper; the first totally agreed with the need to print every updated document. However, the second opinion indicated that it increased the use (and waste) of paper and that it was pointless in that they could access such documents electronically. P10 stated,

> *… for some aspects, the use of paper-based is just making the process slower. For example, considering the delivery tickets, it needs to be automated like other industries. Therefore, we could be notified when materials arrive to check it before having them on our site. We had cases when we noticed a bit late that we got wrong items on site*.

6.2.4.1.5 **Phone Calls:**

These are used to solve a quick issue and report problems quickly. The conversations and agreed actions need to be recorded and confirmed by email. The participants agreed that having a phone call reduced the time needed to sort issues out, and they would like to use it on site.

6.2.4.2 Technological Systems:

The MC organisation implemented the following: a web-based document control system, a site system management system, a snagging system, an Intranet system, and a shared point server to communicate and exchange information among the site parties.

6.2.4.2.1 Snagging System:

An app called SnagR (which is a visual site inspection and defect management system) has been used on a tablet. The site engineer checks the completion of a task and checks for defects on site when they receive a task completion report. They check if there are any defects, take a picture of it, tag the responsible SC and related participants, add a note and select the expected time to amend it, identify who needs to approve it, and then they send it. SnagR is linked to SIMS; it generates a form and sends it by email to all parties involved. The case status stays open till the issue is sorted when it is fixed. From this, the site engineer needs to check and close the case. It could be tracked using SIMS. Although P13 does not like SnagR and prefers more traditional approaches, P06 stated that, *"…it saves more than half of the time that could be needed to do the same task manually."*

6.2.4.2.2 Web-Based Document Control:

The 4Projects system is a control solution for construction documents, i.e. drawings, specifications, photos, and building information modelling. It can be used on site, as it has a field option that the site could access using a smart phone or tablet. It has been used in the MC organisation since 2009; 4project is used to share drawing specifications, schedules or data sheets, and document reports with the SCs, the design team, the MC team, the client and any other parties involved in the project. They receive a notification by email with new updates that they can access, which are uploaded to the system. It could be used for direct discussion but it is not used on the project, as they prefer to arrange a meeting, called a design workshop meeting, to discuss design issues. Due to the size of the project and the number of files, they had 800 drawings at the time of the observation. However, its use was dependent on their previous experience with the discussion option. P03 explained;

> *… we used to have a discussion on drawings but at same time someone was making a comment on the same drawing, which was not included in the discussion. Therefore, it is kind of duplicated information. It is not friendly to use or dynamic in such a busy environment. Because of the number of parties involved, the same issue could have been discussed using many channels of communication at same time*.

For that reason, the design manager used workshops to reduce the number of calls, emails, and discussions. They found this method more productive. P03 said, "*I prefer to meet for one or two hours and save the time that could be wasted on 100 emails and calls to sort out [the] same issues*." It is not used on the site itself; instead, it is employed as a repository for information. Generally, it is considered a helpful method to exchange information. Nevertheless, P06, P07, and P14 agreed that, on site, the potential benefits of 4Projects are not achieved; it is used as a

repository for information despite the possibility that it could help to make huge improvements in the site's efficiency. Figure 6-7 illustrates who has access to 4Projects.

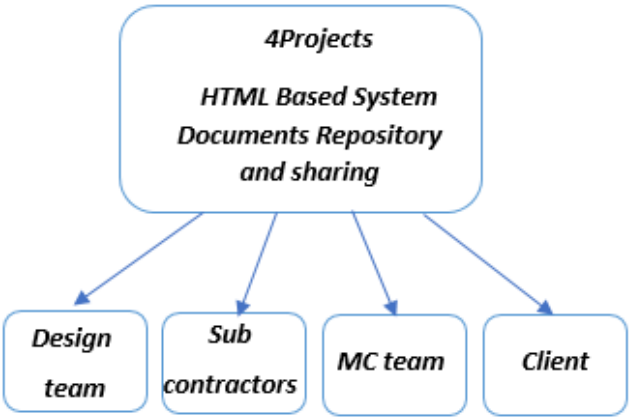


Figure 6-7 4Project

6.2.4.2.3 LYNC:

Lync is a virtual reality system, and a Microsoft program that is used for instant messaging (IM), audio and video calls, meetings, availability (presence) information, and sharing capabilities. It is a voice conference system that the MC organisation uses internally to communicate, discuss and conduct presentations within the team members across the country to save time. P03 stated, *"I wish I could use it externally but I cannot; for the most time, I am using my personal iPad using a Skype account for an external meeting if needed."* P01 similarly stated, *"… if I can use LYNC externally, I could save hours of travelling*."

6.2.4.2.4 Site Information Management System (SIMS):

SIMS is a web application written for the MC organisation to work on mobile devices as well as desktops allowing site managers to record and track information, people, and expenditure from the site. It includes the ability to record site photos and real-time subcontractor communication; it enables all project information to be captured in one place, therefore increasing efficiencies through streamlining processes.

The MC used to include all company policies and procedures that its employees needed to follow internally to report to each other. It considered all projects and information related to the MC company. SIMS is used internally, mainly to conduct the daily site diary report, which is produced by site engineers. Any member of the MC management group and any MC team members involved in the project can access this. Thus, they can follow up the project work by checking the diary and reports generated, and whether they need an urgent reply or action. It

includes weekly reports, monthly actions, inspections, defects, health and safety reports, and information. Therefore, it could be used as follows:

- Internally, as MC employees can access and use it to update and add information or send a reminder for a request to be addressed.
- Externally, as a link attached to an email, which allows the SCs and client to update and replay a report or request sent to them, or see the information they have been allowed to access. However, they cannot add to this, access SIMS or send a request.
- To request information from SCs or clients by generating a form and sending it as a link by email to SCs or the client.
- To confirm verbal instructions, and to distribute meeting minutes by attaching them to the Confirmation of Verbal Instruction form (CVI)

Mostly incomplete tasks were left open, as the form receivers did not comment on the task to close them. However, SCs and clients usually print out the forms and comments, and then scan and attach them as a picture to the case or send them by email. There are some options that were not used on the project. All SIMS information has been linked with SharePoint, which is a file management system saved on the MC organisation server. SIMS is a secure website that no one can access without permission and a password. Moreover, it is not possible to access this from any PCs that do not belong to the company. Figure 6-8 shows the link between the site information management system and other participants.

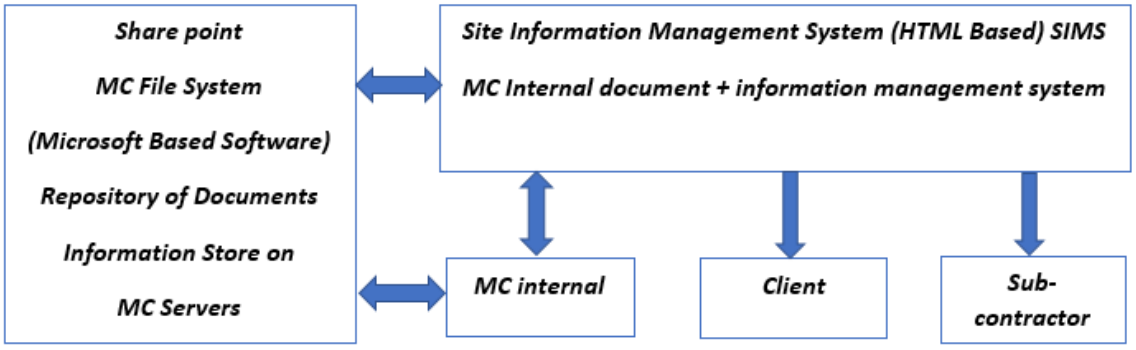


Figure 6-8 Site Information Management System

P07 stated that, *"I have no access to SIMS as a member of the team as I am a project time employee."*

6.2.4.2.5 Intranet:

The Internet is an internal system to share information with MC employees. On-site, the researcher noted that the Intranet has resources that the team uses as training courses. In

addition, they use it to share experiences. P10 mentioned that, "… *it is a good system to collaborate as a MC team, get extra training and share our experiences, but, usually you need an external eye to see that you did something good to share*."

6.2.4.2.6 Emails:

Emails are electronic letters that are used to share information, and communicate on site. All participants agreed that they had a huge number of emails and considered this method of communication an obstacle that needs improvement. Even though it is used as an effective way to exchange information, they mentioned that, "*email protocol needs establishing; too much time is spent on reading unnecessary emails".* P09. P10, P11, P13 echoed this statement.

The MC company agreed to a survey conducted by a group of employees named the 'next generation team' who aimed to improve their internal communication. They checked all applications and systems used in the business, and not just at the site level; the results showed the things the company did well[1]:

- 3% of the responses considered SIMS a good system for use.
- 51% of the responses considered LYNC a good method to communicate within the company.

Meanwhile, the survey results noted the following aspects to improve:

- 26% of the total population said that the email protocol needed addressing.
- 25% selected communication with management as an issue.
- 16% agreed with issues regarding face-to-face communication.
- 11% mentioned that Intranet problems needed considering.

Comparing the capability and use of the systems, it is noticeable that these are not used properly. Moreover, there are duplicated technologies as SIMS and 4Projects are designed for the same use. The most significant difference is that SIMS is designed for MC use only. The team reasons given were that;

- There was a lack of time to look into this in more detail to gain further knowledge.
- They were following the company process in using this technology
- It is not friendly to use, and the team prefers paper
- SCs do not use SIMS, as emails are easier

[1] The researcher decided to only note the figures relating to site communication as the remainder are more internally based and not related to the project site office.

- There is a requirement to hold a hard copy document in the organisation store.
- They prefer older methods of communication and information sharing
- They did not see the benefit of it

6.2.5 Summary of Site A

In general, the communication in site A was described as good. However, the challenges associated with communication were also recognised. In this summary, the researcher uses the following symbols to denote the findings overall;

(☺) Indicates that the aspect is managed in a way that helps to improve communication.

( ) Indicates neutral cases where neither improvements nor problems were identified.

(☻) Applies to cases that need improvement.

1. In relation to the people organisation;
   - Procurement process. ☺

     - The tender process to select the SCs should take consider the history of the SC with the MC organisation, in addition to the regular criteria. They should use a recommendation list to select potential organisations according to their size, culture, and experience.
   - Managing stakeholders ☺

     - Having a good relationship built on trust and honesty to increase the informal communication channels and reduce disputes ☺

     - Considering different methods of management with different SCs according to their size, culture, and knowledge. ☺
   - Contractual relationship ☺

     - The project size and nature ☺

     - The size, location, time of the project and site office design and size. ☺

     - The open-door policy ☺

     - The number of parties involved

     - Health and safety issues

     - Project progress and reports
   - Team structure ☺

- Top management support/involving the site team ☻ This limits the accessibility to information for time-limited project employees, by not involving the construction team in decisions, banning the use of phones, and implementing new technology without proper links to the user level.
- The project manager's skills, experience, and personality ☺
- Team experience, knowledge, and personalities (willingness to communicate) ☺
- Generation differences

2. Issues related to information ☺
   - Distributing the information process (accessible, up to date, and accurate) ☺
   - Requested information process (availability)
   - Approved process ☺

     - Related information as overload, as they use more than one method to deal with and exchange information.
     - The MC organisation uses their knowledge to control and manage most of the above challenges in good practice

3. Technology issues ☻
   - The capability (most of the team do not know the capability of the technology)
   - The need for the technology (they mentioned that they need it to manage to report, for snagging, and to improve communication and the quality of the project) ☺
   - The level of use (they use 4 Project and SIMS, mostly as a repository)
   - Limitations of use (top management decisions, culture for use in specific tasks, a lack of awareness, and knowledge)
   - Technological knowledge ☻

As mentioned in Chapter Five, methods are central to effective communication. According to the interview and observation data, the researcher reviewed the communication methods that site A used as good practice:

4. Methods of communication ☺
   - Traditional

     - Boards ☺

- Radio ☺
- Meetings as face-to-face interactions ☺
- Paper-based
- Telephone calls

- Technological methods
  - SnagR ☺
  - 4 project ☻
  - Lync ☻
  - SIMS ☻
  - Intranet ☺
  - Email ☻

The communication on site A was effective to achieve the goal of the project. Even though, there are areas to improve, this does not mean that there is a communication failure.

6.3 Site B Case Study

6.3.1 Analysis, Presentation, and Discussion of the Data

Table 6-2 gives an overview of the distribution of the respondents across the site office. The main focus of this research is the main contractor's view as they are the controller of the site. However, the researcher interviewed some of SC team members in order to gather a more detailed understanding of the communication process within the on-site office.

(Potential Participants)	Respondents Code	Organisation
Project director	P01	MC (external)
Document controller	P02	MC
Administrator	P03	MC
Construction manager	P04	MC
Site manager	P05	MC
Site engineer	P06	MC
Health and safety manager	P07	MC

Construction manager	P08	MC
Senior QS manager	P09	MC
Senior designer manager	P10	Sub Consultant
BIM strategic planner	P11	MC
Senior project manager	P12	MC
Quantity surveyor	P13	MC
Planning manager	P14	MC
Project planner	P15	MC
Site manager	P16	SC
Site supervisor (logistic)	P17	SC

Table 6-2 Descriptions and Distribution of Interviewees at Site B

MC = Main contractor, SC = Sub-contractor, external = not based on site office daily.

6.3.2 Current View on the Construction Site Team and Parties: Site B

6.3.3 Organisational issues

6.3.3.1 Getting SCs on board:

In this project, the main contractor is an international group that is new to business. They are in the setup process in terms of their company procedures. Thus, their top management are not based in the UK. The Head of Construction Management, who controls and manages projects, is based in the UK. They are the party responsible for getting the project done. They provide agreed services to the client for a set fee over a particular duration according to the contract. Since they hold the agreement with the client for the job, they receive all relevant information and designs. As they are a new company, P01 stated, "… *we need to build up our profile carefully, as our profile is at high risk, to let the client trust us."* The main contractor takes on both their own and the client's duties to manage the site tasks; in order to comply with health and safety law they use their own team and employ external teams as subcontractors. They need to employ sub-contractors to undertake the job for the best possible price for one project. As a result, it reduces the pressure to manage changes to the numbers of people working on site daily as the subcontractor manages their own teams. The role of the SC has been dominant under the leadership of the MCs in construction projects. P01 stated that, "… *we are building*

partnerships with the SCs; if they fail, we will. Thus, we need to collaborate together to get the job done."

As the main contractors are those who undertake the agreement with the client to get the job done, the contractor is responsible to the client for the build job. The job consists of many phases. The MC was awarded the job for phase one, although they still have a tender process for the rest of the phases. As the MC organisation is a new company, they did not have an established list of trusted SCs. Therefore, they created a new process to contract with the SCs. P09 mentioned that,

> *… we have a prequalification survey to be completed to a satisfactory standard. We sent it to the sub-contractors that people suggested according to their past jobs. Once this is agreed, we will send an inquiry out to at least four subcontractors to bid on a set of works that we need to win*.

The methods that the MC used to establish an agreement with the right SCs was to solicit bids from a list of subcontractors who were suggested due to their previous job experience. The subcontractor recommended list was created to gather a list of trusted SCs for work on MC projects. The main contractor's quantity surveyor informally calls at least four of the SC organisations to check their availability to undertake such a job and how much time it could take them to price a job. Then, the MC's commercial department sends the work packing information to the potential SCs by attaching information to an email, or by posting it in a paper-based format. The main contractor usually gives the sub-contractor up to two weeks to price the job and to submit their offer to the quantity surveyor, who will view and discuss it with the project manager and the MC site team to select the SC for collaboration.

The decision will be taken in consideration of their price, pre-qualification questionnaire answers and referrals, which helps the MC to build sufficient information about their average job sizes, work volume, accuracy, level of trust, reputation, safety records, commitment, punctuality and their ability to collaborate with other teams. P08 said,

> *… it is our first project as MC in this company; we did not collaborate with SCs as an organisation, but we did as individuals. We shared our experience to increase the possibility to have a good relationship with our SCs*

Furthermore, P12 stated that, *"… to have a good quality of the work, we need to have a good relationship with the SCs. We are in setting up the stage; we need a supportive SC to help us to achieve the project goals."*

6.3.3.1.1 Pre-contracting at Site B

The pre-contracting stage is considered before the MC and SC sign the contract, and after the selection of the SC. To build a collaborative environment, the method used on site B to communicate is informal meetings within the on-site office. These are particularly important if they are working with SCs for the first time. Such meetings aim to inform the MC team of the situation and to discuss issues that affect both parties. P04, P05, P07, P12, and P16 agreed that it was helpful to attend an informal meeting with the SCs as some had experience with the SCs, whilst others did not. Thus, they said it was a useful occasion to meet and to get to know the teams with whom they are going to collaborate. From this, a formal pre-contract meeting is arranged and recorded to sign the agreement. In this meeting, they will discuss and negotiate contract issues and prices, as well as the completion period, regulation, specification, and other circumstances. The contract formats and regulations follow the JST 2011 Standard of Contracts. P13 mentioned that, *"... according to JST 2011, it is an important stage of design and build process to have a pre-contract meeting, it is a formal meeting that needs to finalise the contract agreement form."* Finally, the contract will be signed and sent to all parties involved, either by email or post. At this stage, the SCs will have access to site A, which is a document control system, and they will receive a notification form when the information has been updated. They will have regular formal meetings for ongoing projects. P02 stated,

> *... when the site work started, we did not have site A on our system. Thus, we used emails to distribute information to SCs. For the new SCs joining the ongoing project, we share information with them using A site.*

SC coordination and management during the operational period are essential to successfully complete a health and safety competence assessment. Therefore, the MC team provides the project with information to promptly meet information requests; check labourers' work permits; provide the SC team with an induction at the beginning of the work to give brief information about the risks, health and safety, environment and quality of workmanship related to site work; and to sort the documentation review and acceptance prior to commencement. P04, P08, and P16 mentioned that they have to lead a morning meeting with SCs, site managers and supervisors. This is a formal meeting with a specific list of attendees, in which they discuss health and safety issues that need to be sorted daily, if any arise. Moreover, they define the working areas for the SCs involved in the work, and share information about the forecasted weather for the week ahead. This helps them to prioritise and schedule the tasks that need to be done according to the weather, which could affect progress. The meeting outlines delivery schedule plans and any other issues that need to be discussed. This meeting needs to be

recorded in minutes and distributed to the parties involved. During the meeting, they have a board to share the information; this needs to be available to everyone who needs it, such as logistics and other areas of work. P16 and P17 agreed that the morning meeting is supportive; it encourages communication and open collaboration channels between the MC and SCs.

6.3.3.2 MC Team Structure.

The main contractor team consists of two parties; the site employees are based in the site office and deal with day-to-day activities. Furthermore, they have a head management team in the main office. Meanwhile, the main team related to the project work exists within the on-site location. For site B, the size of the project is significant as many blocks are in progress at same time. The MC had to build site office cabins to create a working space for their team and the SC teams. The MC team manages the SCs and the project work environment in order to control the outcome quality and sort out the payments for subcontractors. In this project, site employees are those responsible for the commercial and tender parts of the project, and select the most suitable SCs to work with on site. At site B, the size of the project requires a big team who work in different departments; these are the commercial team, design team, management team, operation and H&S team, planning team, M&E team (they were not on the site at the time of the observation), and the administration and document control team. The design manager on site B was a sub-consultant who was not an employee of the MC. P10 mentioned that,

> *I work with the MC as a sub-consultant to manage the design aspects of the MC … I got full access to all facilities, options, and documents of the MC. I even got the MC email, MC business card and personal proactive equipment with the MC name printed on it to use. In meetings, I present them as one of the employees. They deal with me as one of them with no difference.*

They have clear roles and responsibilities, which are allocated according to the Organigram plan, as shown in Figure 6-9. They agree to undertake tasks as a team if required regardless of their role.

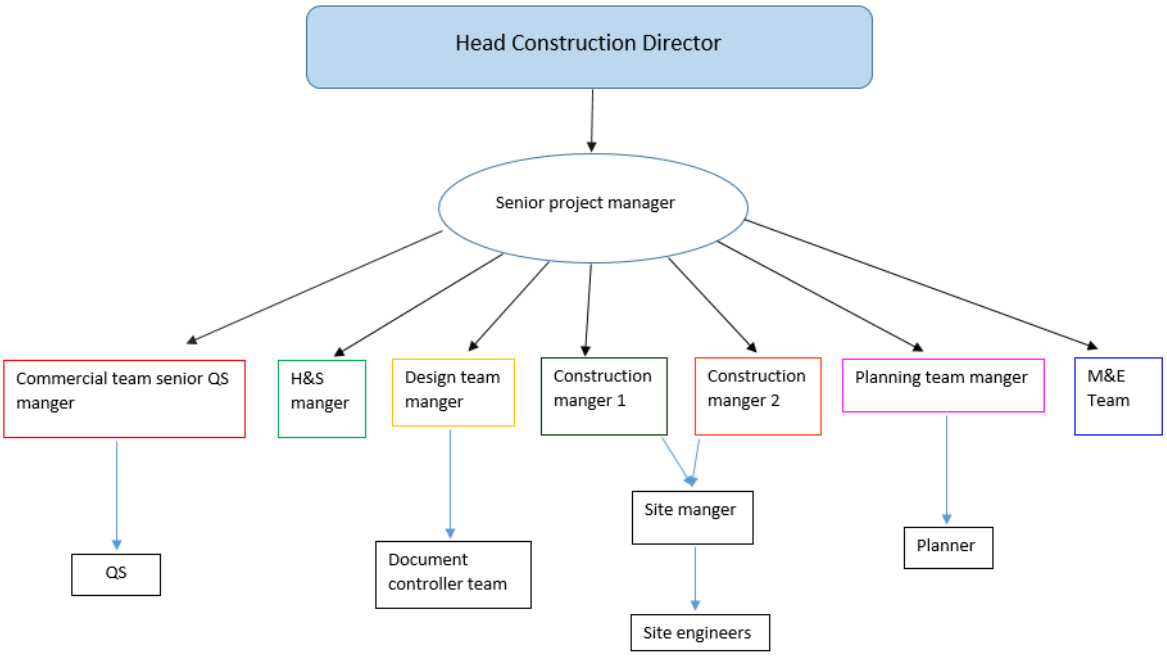


Figure 6-9 Team Site Structure: Site B

The MC is responsible to the client for the building job, including the part performed by the subcontractor. The site team contains not just the main contractor team but also the SC teams, suppliers, specialists, inspectors, architects, and other visitors who work to deliver the buildings, reports, and quality of the work to both the client, and head management team at the MC. Discussions are used frequently on site between the MC team members and between the MC and SC teams; this is facilitated by the open plan design policy of the office.

6.3.3.3 Experience of the Team

Experience is important to develop the relationships and improve trust levels on site at the project. According to participants, a level of experience was one of the requirements needed to get the job. P01 explained that,

> *… to build up our profile, we have selected highly experienced people to work with our team, especially the managers of the team. The reason to request a high level of experience is that they could share the knowledge they have from a different background, which enhances the quality of the team on site.*

The participants agreed that the project manager on site is an expert with an easy-going friendly personality. This enhanced the communicative environment in the site office and encouraged the team to work collaboratively. P15 said that, "*… our relationship with the project manager on site is a very good one. He helps to have a friendly environment in the site office; he is very*

supportive and willing to help." Moreover, P11 also stated, "*I am new on the site; I have noticed that there is a supportive and welcoming environment in the site office*." Whilst P06 said, "… *it is quite helpful to be on site when you can get a learning experience from the management team."* The experience and personality of the PM are essential to improve communication, and to encourage the team to hold discussions to gain a greater understanding of the information. Most of the team members mentioned that they had a good relationship with the team, which enabled the exchange of knowledge and experience. P12 added that;

> *… we need everyone to enjoy their job; it is stressful to be in an environment that you do not like. However, there are some situations when I have to be firm to deal with it. My experience will help me to judge what method I could use to control a situation.*

Having a site team with clear responsibilities, relationships, trust, skills, and experience creates new channels of communication to ease the effective exchange of information. The experience of team members helps to improve the quality of the job. P08 stated that, "… *the level of knowledge in our team helps to communicate and exchange information effectively among the site, even though we are still setting up our procedures and systems*." The team agreed that, as the company is a new MC in business and they are working on improvements. It therefore helps the team to be involved in the decision-making process to develop a good structure and system.

6.3.3.4 The Roles of the Team Members

As the company was at the establishing stage in defining their policies, processes, roles, and networks and in organising the systems they will use, roles and responsibilities were not fixed. Therefore, the team behaved as a group according to their work area. This involved management level, which comprised the Senior Project Manager, the Head of Construction Management, Senior Commercial Management, Project Admin and the Senior Planning Manager. The management team conducted regular visits to the site as the company had just two MC projects to manage at the time of the observation; this made it easier to visit and check the work. The Senior Project Manager was based on site to manage the site team.

Senior Project Manager: This is the main role within the site project The PM is key to a successful project, as they are the leader of the site and support the team during the day-to-day project tasks. P12 said,

> *I have to be involved in all other departments' work to direct, manage and report the progress. I will give instructions on how to sort things out in most cases as I have other tasks to manage. I have to be reported, informed and involved of the issues and decisions that could take place on site.*

The PM role included, but was not limited to: the administrating the project, motivating and managing site personnel, planning day-to-day activities, managing and attending meetings and weekly diaries, managing changes on site, taking decisions, updating the client and top management at the head office with progress, sorting alteration options when an issue arises that needs to be resolved, arranging site visits, communicating with the team and SC teams, helping with design issues, supervising the information flow and task overview, linking the team departments' information, interfacing and presenting, and so forth. Communication skills and experience in handling multi-functional management roles are essential for this role.

Operation Team (including the Construction Managers, Site Manager and Site Engineers): the researcher looked at their roles as a team as their overall aim is to monitor and manage the SCs on site by checking the structural works, supervising the SCs progress (including their labour, and health and safety checks), conducting quality checks, arranging daily morning meetings to help the SCs communicate and work together, checking that SCs are using the latest version of the design update, checking for defects, snagging, compiling daily reports, conducting inspection tests to check the quality, updating site information, checking deliveries, attending and arranging meetings, and checking the logistics of the site. P16 stated that,

> *Checking the delivery ticket, especially for the concrete. I have to check that we got the right type. I have to check if the site engineer had [done] the daily check to the design version that is used on site and it is the last update. As an operation team, we have to check the progress, H&S issues, do the measurement for QS purposes, and many other jobs that relate to site work and SCs' performances and progress.*

P04 mentioned that, "… *we request our SCs do a check of the concrete, for example, and we monitor that the SCs did their check*." Construction Managers, or Site Managers need to spend most of their time on site working closely with the SC team and labourers. P08 explained that,

> *… in the morning we have a daily meeting to discuss what is going on during the day. The SC should share that information with their team; sometimes they do not. We need to keep checking the information on site to reduce the chance of reworking or delay*.

Moreover, P04 stated that he is, *"…working with site engineers to be sure that the project is built using that right information as drawing and specifications*."

The ***Commercial Team*** (Senior QS Manager and QS) are responsible for managing the tender process, checking that the project is still within the approved budget, preparing the bill of quantity for the project, selecting the SCs, sorting out any contract issues, checking the progress of the project, valuing change, assessing claims, negotiating with interested parties, controlling construction costs through accurate measurements of the work required, and applying an expert

knowledge of costs and prices for work, labour, materials and the plant required. For example, P09 explained the importance of continuously reviewing contractual issues:

> *… if any change happened on site, when the construction manager has to make a decision and ask SCs to do an extra job urgently, we need to check the cost and negotiate with the SC to have an agreement on the price of that job as quickly as we can. But to do that, effective communication should be executed to have the information communicated to different departments on time and to act according to it.*

An understanding of the implications of design decisions at an early stage ensures that good value is obtained for the money expended, and that clients are advised of ways to procure the project. P13 stated that,

> *… to sort out the payment issue for the SCs, we need to check the progress and estimate the amount that been done, check for defects [that] need to be done by [the] operation team and we need to be updated. Then we could measure the amount the MC should pay.*

The ***Design Manager's*** role on site is to coordinate the design, including the mechanical and electrical (M&E) elements, and take into account the commercial requirements; therefore, their role is to ensure that the design fits the budget. The designer needs to check the drawing and clarification provided to the site by the design team to ensure they are buildable and include the required information. As the Site Design Manager, drawing approval is one of their responsibilities; they could arrange a meeting with the client or design team to discuss the design issues and the build possibilities in the case of design changes or design mistakes that need to be solved. P10 clarified that,

> *I usually manage the design meetings that take place weekly to check the ability of the design to be realistic and if there are some issues to be solved. We discuss and decide what is the best way to do it; the design will be changed accordingly.*

One of the Design Manager's roles is to go through the approval process in order to have designs ready on time for the build. They work in collaboration with the Document Controller's Department to distribute the information when it is approved.

The ***Planner Team*** (Planner Manager and Site Planner) play a vital role in a construction project, helping to manage both the time and resources to ensure the work is completed on time. The job of a Scheduler is to create timetables for the entire project, which means determining the timing of tasks and when specific materials will be needed. Construction work is often cyclical and delays are normal; thus, a Scheduler must ensure projects are fully staffed when appropriate, and that workers are able to access tools and building materials. If an unanticipated delay arises, the Scheduler must re-adjust timetables as much as possible to avoid

wasting further time and money. This may be challenging, especially given the external pressures from clients, government restrictions, and the Project Manager, as P15 clarified,

> *… the project program should be updated regularly. We have a weekly progress meeting when we can compare, update and exchange the plan information with the SC's planner to compare between both of them and with the internal department that needs to sort out things accordingly.*

The Planner Team for the MC organisation is based in the on-site office, as they do not work on any other project for the duration.

Health and Safety (H&S) Manager: the role for H&S Manager is to set up the H&S policy that the MC needs to follow. They need to compile regular inspection reports on site to check the site performance and to keep improving the quality of the work. This also means ensuring that there are H&S boards on site and in the surrounding areas, and that a monthly issue is produced that is communicated to the site team in general. P07 said, "… *we got a couple of topics related to the time of the year and the most known hazard that could take place. We deliver information related to it to increase the awareness level of it."*

The ***Document Controller*** is responsible for controlling the overall document controller system (A site), which includes all the documents. They select who accesses what information. They deliver a training course for the site team to encourage them to use the site more; however, this still mostly used for design and specifications. P02 stated that, "… *the system is a new process for the MC team to use. I am arranging regular training to explain the concepts of sharing information."* The Design Manager, one of the Construction Managers and the Document Controller are the only individuals who can approve the distribution of documents.

6.3.3.5 Site Office

The site office has an open plan design to encourage an open-door policy where everyone interacts through face-to-face conversations in order to communicate, ask, and check for information. The team agreed that having this design improved communication and collaboration. P02, P03, P05, P07, P16, and P17 agreed that they could get information quicker through the open-door policy. At same time P13 indicated that,

> *… even the open-door policy helps the different departments to exchange their information easily … at the time, it just limits the workspace and the personal space, as you have to listen to everyone's conversations.*

The site office is a two-level building; the ground level is for the SCs' offices and provides space for meetings. The daily meeting takes place in the SC meeting room area; it includes

boards as a method of communication and information exchange. That meeting room is used for site inductions, which are provided by the MC at the beginning of site participants' work; it can also be used for SC meetings. Daily updated boards typically include a delivery board plan for the week ahead, a three-week look ahead program, hazards, and a map of the project to manage logistical issues on site, such as movement, and the workplaces of the SCs. Figure 6-10 shows the design of the site office. The SC team agreed that, as the site office adopts an open-door policy, this decreases the time potentially wasted in sending emails. Instead the SC team can just go to the MC offices upstairs and ask for a form or for information.

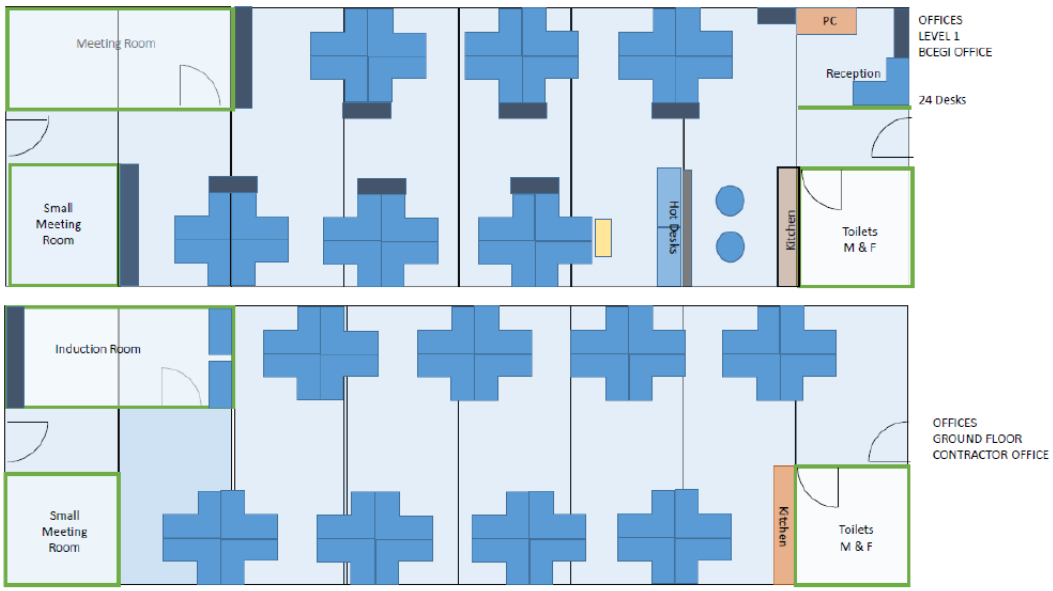


Figure 6-10 Site Office Design: Site B (source: Site B documents)

6.3.3.6 Other Aspects Related to People and Organisations;

6.3.3.6.1 Generation and Complexity:

Increased complexity within the project environment result from the increases in members visiting the site and the organisational numbers involved in the on-site work. In the construction industry, the structure of the team members, specialists and other parties involved in the project come from different backgrounds, companies, cultures, and generations; this increases the distance and reduces the project's communication channels. A different generation may have totally different goals, management methods, experiences, understandings and they may see project issues differently. In comparison, whilst experience helps the older generation to make an appropriate discussion quicker, the tools and technology that the new generation frequently

use help them to act and get results quicker. For example, P12 stated that, "*I have to print the documents out to deal with; maybe it is just my age, but I do like to read on computer screen*." There were 200 people on site at the time of the observation, and the number was increasing daily, suggesting the work would become more difficult to manage.

6.3.3.6.2 Time:

At the time of the observation, there were four subcontractors on-site for the project. One is considered part of the MC team and sorts logistic issues. The MC has a strong relationship with the logistics of the SC. The logistics team helps to arrange the delivery bookings, sorts the movement issues and encourages other SCs to communicate with the MC when needed. The team mentioned that they noticed how various SCs react differently in reporting delay issues. P08 mentioned that,

> *… we experience how time could be critical for some SCs and not to others. For example, when the groundwork SC had a delay, they did not report it and they kept their reported progress as planned, which resulted in a dispute. On the other hand, the concrete frame SC was trying to push the progress ahead even without our direction. They got a collaborative team to sort issues they face on site as quick as possible.*

The number of SCs on site will increase with the development of the project's progress; this will increase the complexity of the project, reduce communication channels between each SC, and increase the pressure on the site to complete the tasks within the planned time and without any risks. The amount of information needed to complete the job and the clashes between the SC who works in the same place will increase. Managing the site and information flows and the SC issues on time are essential. Furthermore, it requires consideration that the organisational management systems differ between SCs as they come from diverse backgrounds with different management processes and structures.

6.3.3.6.3 Managing the Relationship (Trust) with all SCs

P09 mentioned that relationships entail complicated human behaviours. The size of an SC's organisation affects the way they communicate, as there are various communication procedures that their companies use. The project manager confirmed,

> *We got a very good relationship with the SCs; it is based on previous experience and the work that we did together. There is a good and strong relationship, trust and honesty. If you have a tense relationship with your supply chain, things will fail and go wrong. A lot of paperwork and conflicts will take place and slow the project completion.*

P05, P16, and P12 agreed that a trusting relationship exists between the MC and SCs; the MC team agreed that being new in the industry increases the trust between them and their SCs as there is no history of conflict. They focus on the complexity of trust building and the risk of losing this during the project. P05 said,

> *… we are trying to build up a level of trust with our SCs. We can ask them to do extra work even if it includes payment issues and vice versa. The main point is honesty. We have the aim of completing the project on time. Usually, we will inform the commercial team to sort out payment for any urgent changes that take place and that includes costs. We will try to maintain that level of trust, which saves time.*

The researcher observed a number of conversations that took place in the on-site office and aimed to solve issues. These informal communication channels improved relationships. The team was willing to help; it was noticeable that they supported SCs to build communication channels among the SC teams. The easy access to information and its ready availability on site A helped to reduce misunderstandings. This helped to encourage employees to become involved. P07 suggested that,

> *There is box for suggestions in the site office; we asked SCs and their labourers to share their suggestions, ideas or issues that could help to improve the work quality, then offer a £50 voucher which would be given monthly for the best card.*

6.3.3.6.4 The Condition of the Project Site;

The conditions involve the location, site boundaries, weather, size of the project and parties, expectations, and the surrounding environment adjacent to the project. P07 stated that,

> *… we are sounded by a residential area; the environmental requirement should be followed. It controls, for example, the time we could do tasks that involve a load noise, or the time we could use the drones to take site pictures*.

There are many regulations the construction workers need to consider within the project information and contract.

6.3.3.6.5 Contractual Issues:

Contracts are legal documents that control roles and responsibilities, relationships, tasks, communication methods, reports and inspections, and the time of the project. As mentioned in the literature and echoed by P13,

> *… usually we are more flexible in terms of communication; the contract regulation requests a set of meetings and methods to communicate, but we did not have a case when the SC just wanted to stick with the contract communication plan. There is the informal channel taking place on site alongside the project time*.

Informal and formal communication are used on site to exchange information and establish an understanding.

6.3.3.6.6 Operational and Technological Issues:

Operational and technological issues include: the number of parties involved, not having a continuous information flow, accessible information, a lack of knowledge on how to use technology, the size of the task and different understandings of it, health and safety issues, the logistics of the site, feedback, reports and progress checks. The site operation team confirm that the collaboration between the MC and SC improve the quality of the site work. The SCs take responsibility for updating their team, conducting regular checks and updating the MC daily. The MC needs to monitor that SCs undertake and complete their tasks properly with up to date information.

6.3.3.6.7 Top Management Support of MC:

This large international organisation needs to determine the decisions regarding the systems and procedures that the organisation needs to apply. P01 said that, "… *as a UK team, we are trying to state that the industry environment in the UK is a bit different, and that needs to be considered in the decision related to the UK project*." He added that, "… *most of the decisions are linked with cost issues which limit our options*." The MC team pointed out that they have concerns about the decisions of top management, which do not consider them as users. For example, the company provides employees with a work mobile, but the researcher noticed that none of the team thought that the phone they were provided with was a good tool to improve the communication environment. Having a good relationship between the site and head management teams in the UK helped to recognise the need to involve site teams in decisions. For example, the company's next stage was to implement a system to use mobile technology on site to undertake snagging and inspections, to report checks and to access the drawing and information from the site without the need to go back to the site office or call a colleague to check the information. Although site A had the option for their use on site, the site team stated that it was not user friendly and would waste their time. Thus, a survey was conducted among the MC team to suggest a solution for site information accessibility. P06 mentioned that,

> *… we have to print out the drawing when we need to do the progress check and it is impossible mission to do this using paper-based drawings in rainy weather; therefore, using mobile technology on site could save time and increase the quality*

Similarly, P07 said,

> *… I am having a regular H&S inspection, which consists of a long list of issues to check. It is a tick box check; however, it took a day to retype it on the excel sheet to analyse it. The same process could take up to two hours and save my time to work on improving the H&S quality on site*.

The team suggested a system for use that would not duplicate information; however, the final decision was up to the management team.

6.3.3.6.8 Training:

The MC provided its employees and SCs with a training session on how to use Asite, with the aim of encouraging its more frequent use, over email or paper-based communication. P11stated that,

> *… as part of the BIM implementation process, we have Asite as a common data environment to maintain the system to exchange information between the MC, and the supply chain, and we use this to host all the information on the project. Every supplier needs to submit the needed documents on A site*.

P02 added that, "*We need to let everyone involved in the process change their understanding of the effectiveness of using Asite*." Locating a document controller within the site office helped to increase the use of Asite.

6.3.4 Information Management

As mentioned in the previous case, the information was divided into the following sections and used the literature as a background:

6.3.4.1 Distributed information:

Site B's system to distribute information aims to share information files on a document control system (Asite), or by email. On-site, they use printed documents/drawings to check, conduct inspections, convey instructions, and share specifications. They use paper-based methods and Powerpoint presentations as they have facilities to help communicate in meetings. They share information on Asite, discuss daily tasks in the morning meetings and then visit the site to check that the information has been distributed. They distribute information using many

channels of information, which include: Asite, verbal, email, board, radio, phone call, message and, for critical issues, a formal letter.

6.3.4.2 Requested Information (Request for Information - RFI):

When even information is needed, it can be incomplete, missing, unclear, wrong or changed. They request more information; on site B, the MC provided forms to 'request for information', which was available on Asite. The MC and SCs use this form to request information by completing the form and uploading it to the system to be sent to the participants involved. Alternatively, they can use the open-door policy and just ask directly.

The time taken to provide requested information could take up to two weeks. To control the time taken to resolve information requests, the MC uses an Information Request Schedule (IRS). This is an Excel document, which is saved on the shared point server and includes details about the information requested. Asite could be used as an IRS to review information about the request, the date of the request, comments, and the closure of the request. At the time of the observation, as the MC and SC teams were still learning how to use Asite, they use the document controller to help them when selecting the distribution list.

6.3.4.3 Approved Information:

This is a design process to check the drawing, specification, and related documents; this information needs to be checked for approval before distribution. The approval for design information is one of the site design manager's responsibilities. The supplier uploads the design on Asite, which the design team could review and comment on. From this, the Design Manager needs to approve it; they print and comment on it, then scan and re-upload it as an attached file to the original drawing by selecting one of the options according to the workflow system (Figure 6-11). Within this range of options, A means it is approved without comment, B means it is approved with comments, and C means it is rejected. Furthermore, there is an option to comment on it directly; however, the Design Manager did not use this all the time. They said that,

> *Asite is a new system that has been used in the company; it is a bit slow as there is no life document on Asite. You need to download the file, edit or change, then upload it. The use of email still exists, as some SCs do not use it; they still depend on emails. It is just a matter of time to learn more about it*.

They clarified that using Asite improved the approval process and made it easier and quicker. When the information was approved, it was distributed to other parties for use on site as the

final information. In most cases, the MC prefers to select option B, which is accepted with comments. This suggests a culture that shifts the risk in the case of disputes.

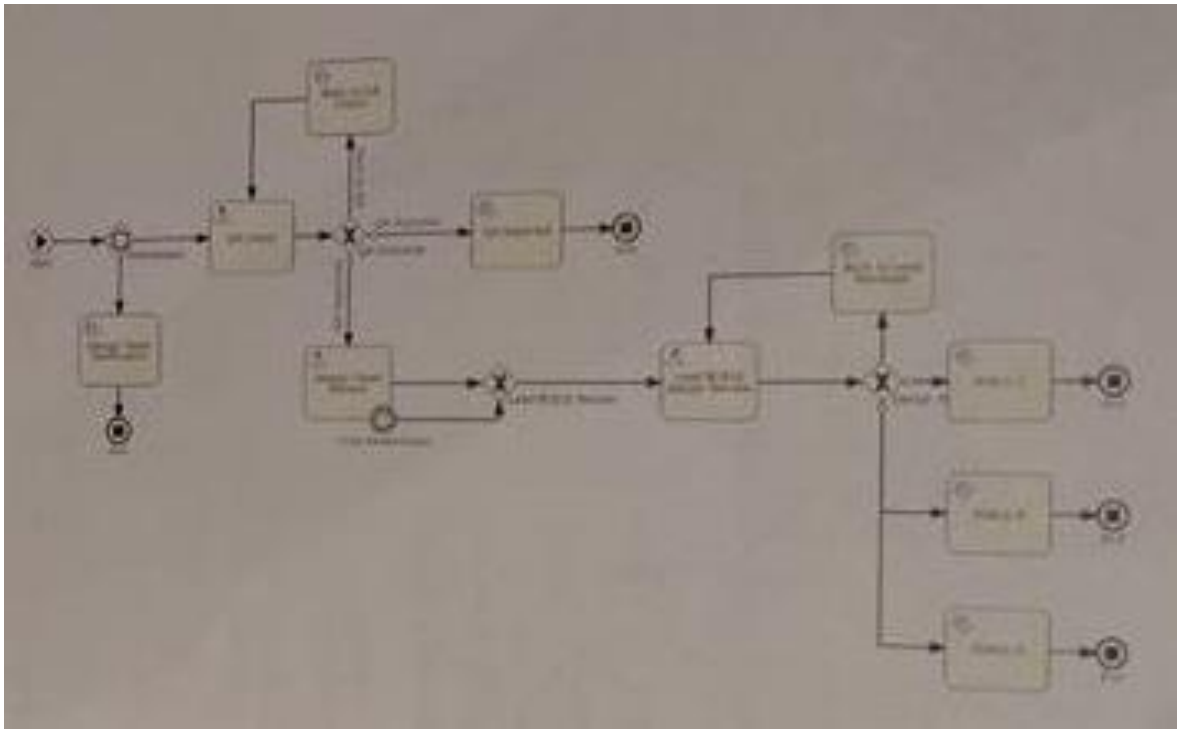


Figure 6-11 Workflow Used on Site B (source: Site B framework)

These three stages are linked to generate an information flow during the construction stage. It starts by requesting information through approval until the task is complete. Figure 6-12 shows the information flow in site B using Asite.

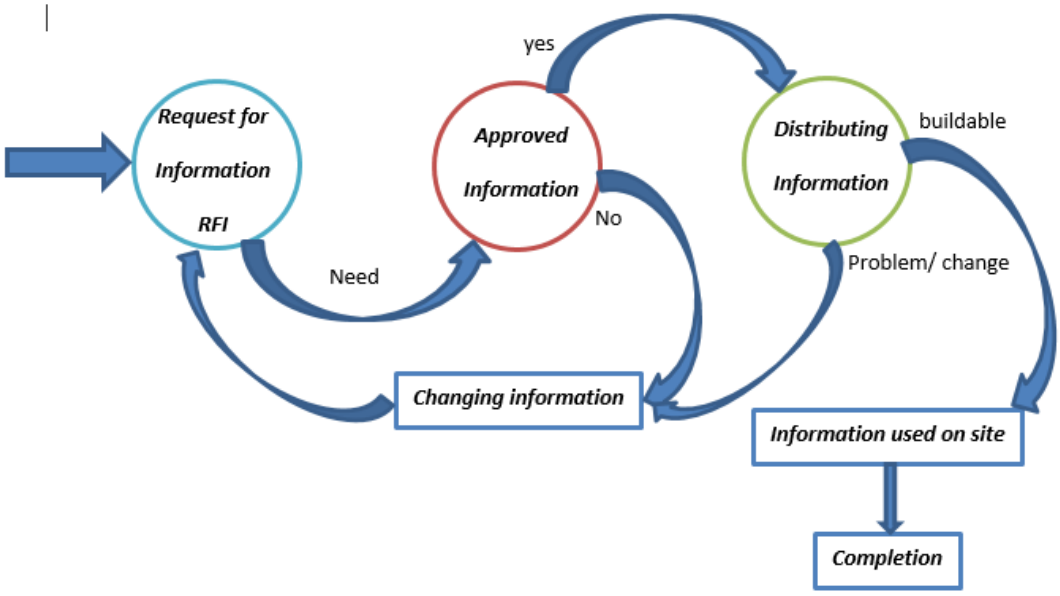


Figure 6-12 Information Cycle on Site B

The MC team agreed that the use of Asite as a document control increased the effectiveness of information on site; however, they mentioned that it is not currently being properly used. Moreover, emails are still used to request information. However, they are adopted during the change process instead of using the capabilities of Asite to exchange information

6.3.5 Communication Media

6.3.5.1 Traditional System

6.3.5.1.1 Boards:

This method is used to distribute information amongst the site and site offices. It is used during a meeting when they need to keep the results available for everyone to see. The board records communication from the morning meeting; this is when the SCs are gathered and have the chance to talk to each other. Information that has been written on the boards included the work areas for each SC on site and the logistical movements on site.

Figure 6-13 shows the boards on site B. These are used to share H&S information. The operation team considers boards an effective way to communicate as it is available to everyone on site. Meanwhile, the H&S manager stated that, "… *using boards or signs for H&S information and hazards could help for a period of time. Then, those boards will not be noticeable as they will be part of the background*." They suggested having electronic signs that keep changing in order to continue to attract attention.

Figure 6-13 Boards On-Site Office B

6.3.5.1.2 Radio:

This method is known as either two-way radios or walkie-talkies; this is a verbal method to communicate on site between the MC and logistics SC team. They use a radio for quick notifications about issues on site. It is used to control access, movement on site, emergency communication, and delivery notifications.

6.3.5.1.3 *Letter:*

This method is used to report a serious issue that affects the progress of SCs; mostly, the issues are out of the SC's control, such as poor weather. Such matters need to be undertaken, signed and submitted within a few days for consideraton. Its purpose is to sort out payments accordingly.

6.3.5.1.4 Meeting:

As a face-to-face method, this has a range of formats; for example, it could be a quick meeting (such as a discussion) that could happen on site to resolve an issue (which is informal, and needs to record whether an important decision is taken).

- *Daily morning meeting*: this is a formal meeting with the SCs where the result is displayed on a board and distributed as meeting minutes (informal).

- *Pre-construction meeting* (attended by the client, main contractor, subcontractor, consultants, specialist and/or other parties involved): These meetings need to be recorded within minutes which need to be shared with all attendees (formal)
- *Construction meeting* (weekly, monthly, or/and on demand): These meetings review progress, provide supplementary instructions (such as site instructions, change orders, change directives and RFI's), discuss and resolve issues, communicate the expectations within contract documents, and exchange technical information. This could be formal or informal, and need to be saved as meeting minutes.
- *Project team meeting*; (weekly, monthly or on demand): These meetings review the progress of the work, the project schedule, progress claims and changes to the contract. It could be flexible as to when it is held and mostly informal. These need to be saved as meeting minutes.
- *Main contractor and subcontractors meeting:* This is held weekly to coordinate the work and solve problems. If formal, it needs to record and to plan ahead.
- *Project closeout meeting*: This is held at the end of work to discuss procedures and requirements for the completion of the project. It is formal and needs to be recorded.

The team considers face-to-face meetings a practical way to communicate information, even though some have considered the use of paper during meetings an issue.

6.3.5.1.5 Paper-Based:

The MC team stated that more than 70% of their communication is paper-based which includes quality checks, material checks, H&S inspections, and other progress checks and reports. They mentioned that they use paper as they are setting up their system; thus, the use of paper will be reduced. Paper-based documents are still mostly used at the site construction office for documents related to: contract letters, schedules, drawings, to add to a folder for use on site, checks on progress on site (in terms of commercial issues), meetings and matters to comment on, reports, H&S checks, progress checks and reports, meeting minutes, and inspections. There were two opinions related to the use of paper; the first totally agreed with the need for its use and to print every updated document. However, the second considered the increase in paper waste and preferred to access such documents electronically. All documents are scanned or rewritten to keep an electric copy on the MC's server.

6.3.5.2 Technological Systems:

The MC organisation implemented a web-based document control system, site system management system, snagging system, intranet system and shared point server to communicate and exchange information among the site parties.

6.3.5.2.1 Telephones:

Employees use the telephone to call, and send Short Messaging Service (SMS) 'texts' or Multimedia Messaging Service (MMS) messages. The MC team stated that using phones is an efficient method to communicate, as it is quick and easy. The use of MMS was predominantly for snagging, while some use SMS to reach people for a quick reply when calls are not appropriate. P16 said,

> *I used calls to communicate with the MC or SC team to hold a quick consultation to solve issues that need an immediate action, I use SMS to communicate with the concrete site manager; he does not answer his calls but he replies quickly to messages. For snagging issues, I used MMS in an informal way to report a defect.*

Calls are therefore used in an informal way but the communicator needs to back up the conversation outcome by email if an important decision has been taken.

6.3.5.2.2 Drones:

These are used to take pictures of the project. It is used by one of SCs and they share the picture with the MC to check the overall progress.

6.3.5.2.3 Snagging System:

The MC was in the process of adopting a new technology for snagging. The suggestions were:

- To use the Asite field version, which was eliminated, as it is not friendly to use on site.
- To use viewpoint (4Projects), which was eliminated, as it would cause duplication of information because it is another document control system. Moreover, it does not synchronize with Asite but replaces it.
- To use *build a safe* application, which is a reporting system that can be used on a construction site for snagging, inspections and to report issues. It could be linked with Asite to synchronise with documents. It could also be used on mobile phones or tablets. The MC team decided to trial it for three months when they could send feedback to top management for a final decision.

6.3.5.2.4 Web-Based Document Control:

Asite is a document control solution for construction documents, namely drawings, specifications, photos, and Building Information Modelling. It could be used on site as it has a field option that the site could access for an additional fee. On-site, it is used to share documents, drawings, and specifications, and there is an option to use it on site to view information without any extra fees. However, it does not support the Windows phones that the team used at the time of the observations.

The design team is responsible for the approval process. There are different views to show the files. Asite sends an email with a list of daily updated documents. The participants can then add a comment to the file or hold a kind of discussion. The MC team is planning to add more information, including commercial, H&S and other information that they could archive as a project on Cloud to save for the future reference. It includes forms for RFI, daily diary reports and other reports. The team is working to increase the use of Asite, even though they confirmed that it is a useful improvement in terms of communication and information exchange.

6.3.5.2.5 Intranet:

They are working on a system to sort out the intranet network, which is at the improvement stage. It is an internal method to communicate, collaborate and provide training resources

6.3.5.2.6 Emails:

Emails are electronic letters that are used to share information and to communicate on site. All participants agreed that they receive a huge number of emails and considered this method of communication an obstacle that needs improvement. Although it is used as an effective way to exchange information, they mentioned that they try to increase the use of Asite instead.

6.3.6 Summary of Site B

In general, the communication on site B was described as good. However, the challenges associated with communication were also recognised. In this summary, and in line with Site A, the researcher uses the following symbols to denote the findings overall;

- (☺) indicates that the aspect is managed in a way that helps to improve communication.
- ( ) indicates neutral cases, where neither improvements not problems were identified.
- (☻) applies to cases that need improvement

1. Related to people organisation
    - Procurement process. ☺

      - The tender process selected the SCs that should be considered, in addition to regular criteria, the history of the SC with the MC organisation, and the use of a recommendation list to select potential organisations according to their size, culture, and experience.
    - Managing the stakeholders ☺

      - Having a good relationship built on trust and honesty to increase the informal communication channels and reduce disputes ☺

      - Considering diverse methods of management with different SCs according to their size, culture, and knowledge. ☺
    - Contractual relationships ☺

      - The project size and nature ☺

      - The size, location, and timing of the project, and site office design and size. ☺

      - Open-door policy ☺

      - The number of parties involved ☺
    - Health and Safety issues ☺

      - Project progress and reports (developing an electronic process) ☺

      - Team structure ☺

      - Top management support/involving the site team ☻

      - The project manager's skills, experience, and personality ☺

      - Team experience, knowledge, and personalities (willingness to communicate) ☺

      - Generation
    - Training ☻
2. Issues related to information ☺
    - Distributing the information process (accessible, up to date, and accurate) ☺
    - Requested information process (availability)
    - Approved process ☺
3. Technology issues ☻
    - The capability (the team has been involved in adopting a new technology; they did not get involved in selecting the phone they use nor the document control system that they operate. They did not access the potential of these technologies as the MC company had to replace the phone in order to use them for on-site monitoring)

- The need for technology (they mentioned that they need it to manage, report, snag, improve communication and the quality of the project) ☺
- The level of use (they use Asite mostly as a repository)
- The limitations of use (top management decisions, a culture of use for specific tasks, a lack of awareness, and knowledge)
- Technological knowledge

As mentioned in Chapter 5, the method of communication is central to effective communication. The researcher reviewed the method site B use as good practice according to the interview and observation data:

4. Methods of communication ☺
   - Traditional methods
     - Boards ☺
     - Radio ☺
     - Meetings as face-to-face interactions ☺
     - Paper-based
   - Technological methods
     - Mobile telephones
     - Asite
     - The Intranet
     - Email ☺

The communication on site B was considerably effective at achieving the goal of the project. Although there are areas to improve, this does not mean there are communication failures.

Chapter Seven: Findings, Conclusions and Recommendations

7 Communication in the Case Studies

This chapter used the data from Chapter Six to illustrate and discuss site challenges for effective communication. Triangulation was achieved by referring to the literature review, the survey findings and through the conduct of comparator case studies. In this chapter, the researcher will address the research questions that guided the triangulation and thus the research validation. These questions helped to analyse and discuss effective communication in the case studies' projects by asking:

- How were stakeholders in the case studies identified, and how important was it to improve communication?
- What was the link between the project nature and the channel of communication used to exchange information?
- How did the team structure on site effect communication?
- What information process was adopted throughout the lifecycle of the project?
- What technology did the team on the case studies use?

In this chapter, communication in the case studies was analysed to enable a deep understanding of the situations and to link this with the questionnaire analysis. The initial analysis concerned the mode of communication from which many media were identified.

7.1 Background of the Pre-Contract Stage;

In both cases the commercial team described the importance of the tender process for the selection of SCs, which for both cases was based on the perspective of experience and enabled the development of a recommended list. They both use the same standard for contracting, namely design and build (Figure 3-3). Even though Site B is a new firm in the business, they still define their list of recommendations. The category that both sites considered when adding SCs to their lists was experience; while Site A used their background as an organisation, Site B used their individual experience. Thus, the criteria for selecting SCs is considered the first step in the improvement of communication on site as both cases agreed that working with subcontractors with whom the team are familiar could improve the quality of communication among stakeholders. According to both cases, there is a need to select the right subcontractors. Within a construction project, time is a critical factor in reducing the possibility of conflict. Additional time could increase the cost of the project and reduce the benefits that the main

contractor gains. Therefore, according to the case studies' project managers, the reasons for a list of recommended SCs are:

- To build and maintain good relationship with particular SCs,
- To reduce disputes,
- To increase informal relationships between the MC and SCs that are built on trust,
- To reduce the time needed to approve information,
- To adopt formal communication to document the results.

Moreover, the literature highlighted the importance of selecting stakeholders in order to define the type of contractual relationship between the MC and SCs. This is based on the belief that selecting SCs wisely is essential to improve communication. Nevertheless, although previous experience is important in building a level of trust, it is not enough to select SCs. This is due to the following reasons; firstly, other aspects should be considered in terms of the reputation of the SC, their profile, and the type of job they are going to do; secondly, both projects have their own contract processes. As such, the contract simply represents the first step in the communication process.

The contractual stage creates two channels of communication between the MC and SC, which are: Formal, or based on the contractual relationship, and informal, or based on previous experience and trust. The number of SCs working on the same project depends on the nature of the project, its size, time and budget. However, a change of contracting process policy requires an increase in the use of electronic information exchange and a reduction in the use of paper to thus speed up the process of information sharing and ensure it is available when required. Both of the case study projects use the JCT contracting standard, which requires essential investment to define the responsibilities, the ways of working and the documents for archiving. In both case studies the communication was described as good and effective; this referred to:

- The quality of stakeholders involved in the project.
- The communication skills of the team.
- The quality and experience of the staff in the site office.

7.2 The Project Natural

The literature review noted the complexity of the construction industry, and that researchers differentiate between other industry and construction processes. In both case studies, the 'product' involved was a building project; however, this required steel structures on Site A and concrete structures on Site B, which entailed different types of SCs, supply chains and

materials. Whilst both sites have the same type of contract, the specifications, drawings, project documents and building methods are different. Thus, Site A had space limitations surrounding the project, which limited its access and meant a number of stakeholders and deliveries were working at same time. In comparison, Site B had an open space, which allowed for more equipment and stakeholders to work at same time. The total time period of the projects differed, which reflected in the amount of work required and the parties involved.

The location of the project had an influence on the project management; a project needs to meet a range of regulations and requirements including environmental, neighbourhood, health and safety, and so forth. This was reflected in the relationship between the MC and the SCs. Site A existed in a residential and commercial area, whilst Site B existed in purely a residential area. Such differences were reflected in the time taken for the work and the communication within the neighbourhood.

The size of the project controls the number of tasks and the size and number of SCs involved. Site A was considerably small compared to Site B, which was a mega project; this had an effect on the size and number of subcontractors. There were many small organisations working as subcontractors within Site A, which meant an increase in the communication challenges as some stakeholders did not have the access to electronic information during times of change. They used to have access to shared information once a week, which increased the effort required from the site office team who needed to ensure that all stakeholders were working on the latest information update. Site B had bigger stakeholder organisations working within the project who had access to all the information shared. However, the main contractor team had to keep checking that the information on site matched the latest information update.

The project budget reduces the flexibility in selecting SCs. Both projects were considered large; Site A was smaller with a shorter time period while Site B was a mega project with a longer period of time. The main purpose of the project was to increase the profit of the main contractor; this could be gained by attracting the best subcontractor at the best price. Therefore, the project budget played a key role in defining the stakeholders, the technology used, and the size of the team involved.

Generally, the complexity of construction projects impact on the size and number of SCs, the environment on site, and the relationships and management systems used. On the other hand, having a multi-organization culture increases the complexity of construction projects; thus, the more complex the project, the more formal the relationships. The MC and SCs will work closely during the construction stage, and the site office design and size relates to the project location and size. In both cases, the main contractor had an open design office, which enabled

an open-door policy and promoted a willingness to help and collaborate. Although some participants considered the open-door policy a disadvantage, the majority found that it improved communication on site.

7.3 Managing Stakeholders

7.3.1 Manager and MC Team Skills

The participants agreed that the experience, knowledge and personality of the project manager affected the outcome of a project. This role was understood to direct and lead the team, either by managing an internal team in the MC office or by externally managing the project through directing and monitoring the SCs. The manager's experience, knowledge, leadership methods and communication skills were found to help:

- Improve the level of trust, honesty and collaboration with the SCs and the relationship amongst the project stakeholders;
- Improve the quality of projects;
- Solve disputes;
- Enable the clarification of tasks, the development of a reasonable plan, and explain roles and responsibilities.

A skilled MC team is key to managing a project's efficiency. The roles and responsibilities of the MC help to organise the project process. The researcher defined the role of the team on site and noted that it was attached to a set of information to address, for example, the commercial team, who deal with the SCs and define the contractual relationships. This includes; the contract, the set of work that needs to be delivered, the progress checks and the payments. The site team come from different generations and different backgrounds, with diverse knowledge, experiences, disciplines and skills (indeed, sometimes they were from different organisations). However, they all need to cooperate in order to achieve the project goals; accordingly, this increases the complexity of the project.

From the case study results an important issue related to the team structure was mentioned; on Site A, one of the project team employees only had limited access to information and facilities as he used to be an external employee, while Site B provided their sub consultant employees with full access. By comparing the circumstances of the case studies, full accessibility to the required information for all members helped to improve the quality of the information exchanged, the team relationships and effective communication amongst the team members. Site A's main contractor dealt with its external employees as subcontractors, with limited

access to the core information that the team worked on; as such, they needed to ask a colleague to share information when required. Having limited access reduced the quality of the information shared. Meanwhile, Site B dealt with their sub employees in the same way as their internal employees in giving them the same access; this access increased the collaboration among the main contractor team.

Top management were involved in the sites. On Site A, feedback related to top management was not supportive; there was no communication between the site team and top management, whilst the decisions taken by management affected the work that took place on site. These decisions included banning the use of mobile phones on site. Thus, the decisions of top management influenced the quality and process of the project, which included:

- Deciding what procedures and processes the organisation needed to follow;
- Limiting the communication channels used to take place on site;
- Ensuring technology was used on site without considering the site's associated needs and issues.

In comparison, on Site B, and because the company was still new, it was easier to notice wrong practise and unhelpful decisions and to adopt a new management method. For example, phones bought for use on site did not have the capability to access the required information; therefore, the adoption of Asite as a shared document system was criticised. The site team suggested what they needed to improve the quality of the job. The differences between the top management processes in both projects showed that consulting the team on the site could increase collaboration and encouragement among the site employees.

A comparison of the data from the case study and literature review shows the importance of the following in developing effective communication:

- The knowledge, skills and experience of the project manager.
- Improvements in the communication and collaboration between top management and the site team.
- The knowledge and skills of the site team.

To maintain a good relationship with the SCs, the main elements that affect the relationship are detailed in Figure 7-1

Figure 7-2 Aspects reflecting the main contractor and subcontractors relationship

7.3.2 Managing the Relationships with SCs

The MC and SCs have a goal and in order to achieve this, they need to communicate the project information among the parties involved; furthermore, the effective management of the project could be achieved by managing the project parties. It is the MC's responsibility to create a culture-sharing environment on site; thus, shared SC workspace offices represent one method used by the MC to bring parties together. Furthermore, SCs need to align themselves on site to complete the work; in other words, they need to communicate to agree on the work area on site, which includes the delivery time, storage, and movement on site. Therefore, the MC usually arrange an 'event' for SCs to communicate; both sites held morning meetings to ensure that the daily arrangements took place between the SCs. However, the meetings did not use the same channel of communication. On Site A, informal meetings were held closer to the workshop; they were not documented but used boards to share their daily arrangements. On Site B, formal documented meetings were held using boards to discuss the working area; they shared the meeting minutes among the parties by email or Asite. Nevertheless, the concept of daily communication existed on both sites, and these processes brought stakeholders together to communicate and share knowledge. In both cases, subcontractors had some open plan offices that enabled communication within the site environment. These were accessible to all SCs and the main contractor to ease communication among the project stakeholders.

7.4 Information Management;

In terms of information, the literature review in Chapter 3 clarified the important characteristics for effective information. The site team confirmed that information needed to be accessible,

accurate, up-to-date and buildable to enable a successful project. The researcher divided the information according to the following statuses;

7.4.1 Distributed Information

The sites used different ways to distribute information; nevertheless, they agreed that information should be shared among stakeholders and that it should be up-to-date and approved. To share information, teams used many means of formal or informal communication. Regardless of the method of distribution, it was confirmed that the information needed to be available to all stakeholders involved. Both projects agreed that their companies employed a document controller to ensure the accessibility of information by the right persons at the right time. They updated the information and sent an email to inform the stakeholders of the latest update. Although the teams agreed that it was an effective method; they mentioned that the amount of emails received was huge which meant most ignored messages and sent them to a separate folder to ease their management.

7.4.2 Requested Information

Sites have a slightly different procedure to request information but share the same purpose, namely to access required information. Site A use their own system (SIMS) to generate an RFI form that they send to participants who need to act on it. They oversee the RFI process by using an Excel sheet, named an Information Request Schedule (IRS). They commented that they found these methods efficient. In comparison, Site B use the document control system to access the form. They re-upload it to Asite for sending to the selected distribution list. Both sites agreed that their process of requesting information was effective but that it was a long process as it could take up to three weeks in some cases. As such, they preferred to request information directly from the stakeholder responsible for its provision.

7.4.3 Approved Information;

Both sites use exactly same the process but with different tools; Site A uses 4 projects, while Site B uses Asite. Furthermore, the same process takes place; the document and drawing are uploaded by one of the supply chain members so that the design teams can view them, comment on them, and request a meeting to discuss the details if required. From this, the design manager has to select one of the approval options, which are accepted without comments, accepted with comments, or rejected. The main aim of the approval process is to check that the design is buildable and to reduce issues on site or rework. After this process is complete, the information will be used to create the physical building, which is the last step of the information journey.

From this, the checking process will take place; this entails checking the progress, its defects (snagging) or the completion of the task.

7.5 Communication Media

The sites used different methods to communicate; each method had its use and benefits; however, the effectiveness of such methods differ according to their application. The same method could have different feedback in two different environments; thus, the complexity of a project, situation or communicated information has an impact on the method.

7.5.1 Boards/Signs

This is an informal channel of communication and usually adopted for discussions, such as on Site A during the morning meeting. Moreover, these could be used as a sign to share information with the surrounding environment. Site A considered this an effective method to communicate, whether as a board or sign. In comparison, Site B considered this an effective way to communicate during a meeting but ineffective as purely a sign; they explained that after a period of time, it would not be noticeable.

7.5.2 Radios

Known as walkie-talkies, these represent a verbal and informal way to communicate and are used for the quick delivery of information, such as informing the site manager about the arrival of a delivery. It is a verbal instant message and considered by both sites as an effective as a means of communication. Site A uses the radio as the only way to verbally communicate on site while Site B uses it alongside mobile phones.

7.5.3 Meetings

These are a face-to-face method of communication and could be either formal or informal; the meeting could happen between individuals, such as via a conversation, or it could occur in a more complicated situation, for example, in a multi-organisation (e.g. design) meeting. On site, it has been frequently used for arranged formal meetings or informal meetings.

In the case of formal meetings, these need an agenda, a list of potential attendees, a plan of progress and the topic that will be discussed including who will manage it. Such meetings need to be documented and the minutes need to be distributed. In comparison, informal meetings are mostly undocumented unless an important decision has taken place. According to the literature review, face-to-face communication is one of the most effective methods of communication. The case studies confirmed that, in Site A, the team prefer to arrange a

workshop to discuss important issues rather than deal with any other media of communication. Similarly, Site B team prefer to visit the site or the SC's offices to communicate; this enables a quicker outcome than other methods. They both agreed that they hold informal meetings to communicate information.

7.5.4 Letter

This is a very formal written method to communicate and used when signed information needs to be communicated. Both sites mentioned that the use of letters means there is serious issue that needs to be addressed. These are mostly used in the case of conflict or if the contract requires such methods.

7.5.5 Paper-Based

The use of paper-based communication is usually associated with other media to deliver a set of information on site, such as meeting minutes and drawings. It was mentioned as a way to exchange information in reference to the act of communication. Site A uses this method for inspections, reporting, documented drawing/site checks, specifications, instructions, schedules, meeting minutes, the contract and delivery tickets. They consider it an effective method to exchange information in most scenarios but indicated that it could be very slow. For example, if used with delivery tickets, this could only arrive two days after delivery, which (in case of wrong delivery) is very late for action. In comparison, Site B used it for almost all kinds of information at the beginning of the project when they did not have alternative options. They stated that they used it for documentation purposes or for temporary use (reading, for example). They subsequently reduced the use of paper and tried to increase the use of electronic information.

7.5.6 Phones

This is an informal way to communicate. The use of mobile phones on site is banned on Site A; they can use a telephone from the site office, although most use it just for calls following which, the information exchanged in the call would be documented and sent by email if necessary. They consider it an effective method to communicate. However, they 'wish' they could use mobile phones on site. Meanwhile, on Site B, they use mobile phones more often to address emergency cases on site, to snag using MMS, and to send SMS when needed. The outcome of this phone use may be documented if necessary. They consider it an effective way to communicate. Both projects agreed that the use of phones on site could be efficient if employees could access their shared information based from the site. Site A banned the use of

mobile phones on site, and while Site B can use their phones they cannot access shared documents as the quality of the phones will not allow for this.

7.5.7 Emails

These are an electronic letter to share information; they are used either formally or informally. In Site A, email is used for many things; it tends to be used as the main method of communication. They consider it an effective method to communicate. However, it is overused and there is a need to control the number of emails received daily. Participants mentioned that some emails are received automatically as a notification from 4projects or SIMS. Furthermore, Site B shared the same belief; however, they mentioned that they are in the process of shifting all shared information to Asite to reduce the use of email. In general, the use of email is considered an effective, easy and cheap way to communicate. Findings from both sites agreed that email use needs to be controlled and minimised as they found it difficult to read and maintain an awareness of all messages received. This issue was particularly prevalent amongst the project managers who could receive more than one hundred emails daily.

7.5.8 Lync

This is a virtual reality system used for instant messaging, audio calls or videos that enable internal communication on Site A. It is used for formal and informal communication and Site A considered it an effective communication method. In contrast, Site B did not use it. Although it could be more effective for external use, top management decided to only use it internally.

7.5.9 SnagR

This is an application used on Site A to snag defects; it could be used as a visual site inspection and defect system. Site engineers use it to report a defect; it is linked with SIMS so they can check the status of cases using SIMS or the SnagR application on an iPad. Although the older generation in the company did not see the point in using it, the younger generation consider it an effective communicate approach. In Site B, they did not use it for inspection although they planned to do so.

7.5.10 Site Information Management System (SIMS);

This is a web application designed for use on site in the organisation of the main contractor. Its potential lies in its use on site via mobiles as well as desktops, as it allows the site team to record and track information, people and expenditure on site. It could be used for snagging or real-time communication. On Site A, they just use it internally from the site office for the daily

diary of the site office at the end of the day; this includes RFIs, which could be sent to any participants involved on the site work. It is considered an effective way to communicate even though they do not fully use it. Instead, they use it as a repository rather than as a tool to communicate.

7.5.11 Web-Based Documents Control: 4 projects/Asite

These are document control solutions that enable construction companies to share documents, namely drawings, specifications, photos and Building Information Modelling. They could be used on phones on site; however, neither sites use them in this way. Site A mostly uses 4projects to share drawings, specifications, and instructions between the MC, SCs and suppliers. It is used as a repository as it is employed in the site office to check the latest update and to print it out for addition to a file. In comparison, Site B uses Asite to share information with its supply chain, that includes RFIs and approval processes. Asite could be used on site, but because it is not friendly to use they do not employ it on site. They mentioned that they adopted it as a part of a BIM implementation. They are trying to encourage the team and supply chain to use it by providing training courses on Asite.

From the questionnaires and case studies the researcher found that people in different positions preferred different methods of communication. Most members preferred a face-to-face method as the main method of communication. It was used to solve urgent issues on site, resolve problems and develop effective solutions that could be documented later if needed. Both case studies confirmed that they used an informal method of communication on site to agree the site activities.

7.6 A Critical Review of the Effectiveness of Communication Using Technology

The importance of communication is recognised in both projects by respondents. They agreed that communication could be one of the major project success or failure factors. This reflects the understanding of the team and site staff on the importance of effective communication and information management. This part of the study reviews the use of technology used on both sites.

On Site A, they use four applications and systems, namely Lync, Snag R, 4Project and SIMS. Figures 6-7 and 7-7 compare their potential use. As it is designed to cover the concept of site management, SIMS could theoretically replace 4projects, SnagR and Lync as it allows the user

to share information, run reports, conduct snagging and hold real-time communication. It claims to reduce the time needed to access information on site. In reality, its use on site is internally limited to site office use. All information on SIMS is linked to the server for archiving; even though the most important and essential use of technology is on site, the team agreed that they do not use the options available. As time is critical in the construction industry, construction teams tend to be busy; therefore, the technological market sells construction products by claiming to enable workers to achieve what they want and can achieve. Thus, on site A there is:

- Duplicated information, as Figures 6-7 and 7-7 show.
- An underestimation of the capability of their current technology.
- Waste, as a lot of technology is not used to its full potential.
- An overestimation of their needs for technology on site.

Site B used Asite and linked it with their server; they had a full understanding of its benefits. However, it could be reasonable to increase its use. Even though Asite has the option to deliver the information on site, Site B decided to buy another application. They stated that Asite is not friendly to use on site and their phones did not support its access due to a lack of storage. They chose to buy the application to help them view documents and drawings, and conduct inspections, health checks and quality checks. Therefore, the cost of using technology on site could increase, with the same resulting problem namely the duplication of information.

Emails were mostly used on both projects, although the teams have mixed feelings about their use. Even though they agreed on the importance of email to exchange information, they were overwhelmed by the time needed to read and understand the detail of each message. They agreed it has its advantages and disadvantages. Participants mentioned the need to adopt different communication methods. Construction projects sites are driven by changes and urgent problems that need to be resolved time regardless of whether they are issues that stop work, contractual problems or financial concerns.

In summary, both formal and informal communication are used based on the information involved and people participating in the conduct. They are important in any project and could be applied through different methods of communication and information exchange; these methods cannot be used separately.

8 Conclusion

8.1 Introduction

This session reflects on the research as a whole. It starts by synthesising the key findings of the research in terms of the basic framework, and reintroduces the literature from Chapter Three. Furthermore, the communication results from site offices are presented alongside the research aim and objectives. After this, the research questions are reviewed and briefly answered. The contribution to knowledge, both theoretically and practically, is presented whilst research limitations are highlighted, and the recommendations for practice and future research are outlined.

8.2 Synthesising Key Findings of the Research

8.2.1 Revisiting the Basic Understanding (Framework)

Chapter Three introduced the basic framework by displaying the link to effective communication within site offices. The framework has three elements - people, information and technology - and is illustrated in Figure 8-2, which uses black arrows to link the elements. In summary, the information (drawings, specifications, instructions, etc) needs human resources to deliver it. For a construction site office, there are teams (managers, engineers, subcontractors, supervisors, etc) and individuals who are responsible for the management of information flows (arrow 1). The latter group was termed the stakeholders. Legislation under the information element has an impact on the type and relationship of the stakeholders involved. For example, the trust between stakeholders and site teams is attributed to the method of managing the information flow, the leadership skills and the organisational structure of the main constructor. The structure of the information flow, and the contract agreements provide a communication plan to manage the project. These stakeholders then operate certain activities to deliver their tasks on time with the support of technology that helps to ease the delivery of the information needed by stakeholders (arrow 2). The level of technology and the techniques used reflect the effectiveness of communication on the site office and the management of the information flow (arrow 3). This, in turn, affects the people who deliver the tasks. For example, a change in the technique used to deliver information alters the way that the procurement is undertaken, eases the process of contracting and enables access to the required details by other stakeholders. The three aspects are attributed to the channel of communication used, the site environment, and the relationships amongst the stakeholders.

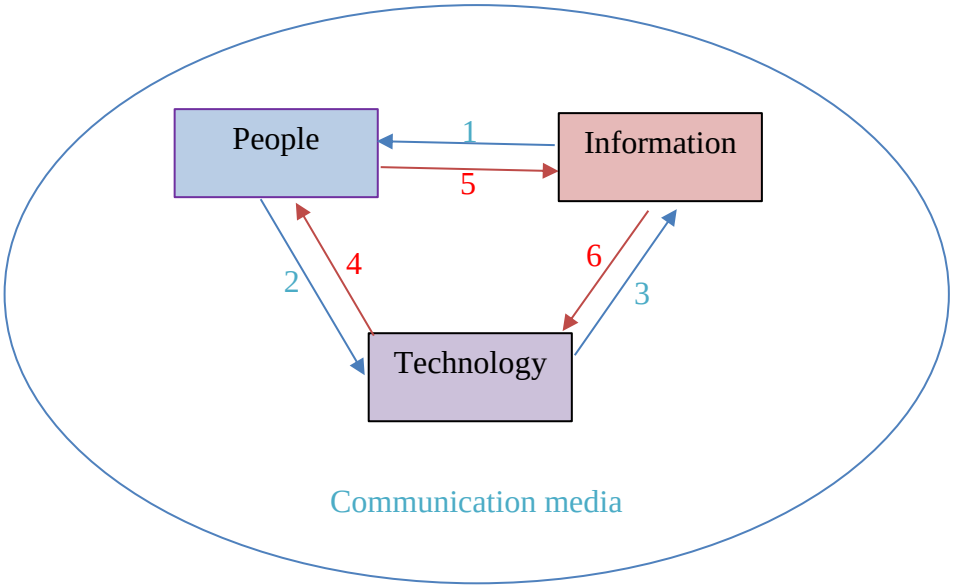


Figure 8-1 The interactions between the three elements (Basic Framework)

The interpretation of the data in terms of the complexity dimensions and concepts (Chapters Five, Six and Seven) further describe the relationships among these three elements, as follows.

8.2.1.1 At the Level of Individual Elements:

The information element includes the following aspects (variables): the quality of information, its production, commercial information, and uncompleted information. The chain of providers involved affects the structure of the information flow, the information management and the information checking policy that they operate. These were initially identified by reviewing the literature (Chapters Two and Three) and then expanded and solidified by analysing and coding data from the questionnaire, interviews and observation transcripts. Each of these aspects affect and are affected by the other; for example, the distributed information results in the processes and techniques to request information. This, in turn, increases the time taken for the task in order to approve the required information. In addition, the method of the information request affects the stakeholder's access by stressing the team at the expense of the time to complete the process (see Figure 6-4).

The people element includes performance stakeholders and the team who work on site. As seen in the literature chapters and supported by the data analysis, this element is associated with top management policy; the types of behavioural complexity seen in the variety of relationships types; and the prioritisation of measures, perceptions, learning, innovation, trust and experience.

Chapters Two, Five and Six show the different variables related to each element, which are organised into groups. These variables are not exclusive as other variables might emerge. A good example is the external staff under the people element. The percentage of external staff on construction sites could be higher and this has both advantages and disadvantages. Moreover, the rules by which these variables interact through communication are not fixed. The exact relationship between the trust levels and the frequency of fruitful cooperation is dependent on the people involved and their personalities. These are characteristics of a complex system where the variables interact, and the rules of the organisation's top management interactions are subject to change.

The technology element includes the new systems and methods that the main contractor adopts to exchange and deliver information to the stakeholders involved in the project. In the literature review, the need for technology and changes to the traditional method of information exchange has been discussed and clarified. This has been supported by questionnaires and the observation analysis in order to understand the variables that face the implementation of new technology in construction site offices. These variables include the training time required, the cost of change, various technological options, and the mentality associated with the rejection of change. The use of technology is linked to the media of communication that is used to exchange information; this varies from traditional to up-to-date methods.

8.2.1.2 At the Framework Level

The insights from the data regarding the relationship between the three elements are reflected in the red arrows shown in Figure 8.2. Arrow 4 reflects the use of technology to communicate, which is seen in the interdependence and differentiation among the diverse stakeholders, and leads to behavioural complexity. This has been illustrated in Chapter Six in terms of the fluctuating levels of trust, sharing and negotiation, and the interaction between these and some levels of management (inspection reports). Arrow 5 represents how people's behaviour, which is already affected by the information flow management and contracts policy, leads to the prioritisation of information sharing. This, in turn, feeds into perceptions over the project function (as an aspect of the plan). In other words, the prioritisation of information access over purposeful activities stresses the project performance on site and vice versa. Arrow 6 represents the effect of several aspects of technology and techniques on the information flow and site operation. For example, the new methods of snagging brought about by UK policy, affects the ability to update and change quality inspections. Both health checks and inspections were traditionally paper-based, and organisations were reluctant to change contract policy and

technique in order to avoid management changes and conflict and negotiation. Another example is the effect of the stakeholder's contract on the focus given to certain activities during the specification changes (see Chapters Five and Six).

The inferential findings of the research also provide further insight into the nature of the relationships represented by the blue arrows. Arrow 1 also presents the process of exchanging information on site, with particular regard to access to specifications and information on the project function and the delivery of information to stakeholders. Arrow 2 re-stresses the impact of these different perceptions (behavioural complexity) on the assumptions and definitions held by different stakeholders in relation to the use of technology. It advocates that these should be controlled and centralised on the project site. Arrow 4 stresses the influence of certain people and organisational structures on shaping and informing the data in relation to competition. Thus, combining the red with the blue arrows illustrates the feedback (double-headed arrows) between these elements.

All the above elements are subject to change through time and context. The dynamics of the relationships (arrows) take time to materialise and lead to self-organisation within the site offices. For example, the dynamics of interaction between people and information exchange emerges under the technology element (to improve the exchange of information between the stakeholders). The main contractor is usually the core of the site management process and controls the interactions amongst stakeholders. This affects their behaviour and aims to achieve a level of trust that improves communication in site. This is seen in the way some project managers are self-organised in relation to project successes.

The context also dictates when certain techniques and communication media prevail, such as the use of document controls and relationships with the provider. Moreover, at a certain point in time, the information exchange in site offices is seen in the context of site management. The media of communication used on site affects the way people behave in relation to learning. Hence, all interactions between the three elements should be seen in the time and context of their occurrence. This means that improvements in the relationships amongst stakeholders through the increased use of technology encourage a better exchange of information, which is controlled by time and context. In other words, this is linked to the complexity of construction projects. Time is seen as the dynamic between different aspects (variables) under the three elements. Contextual complexity reflects the context within which information interacts with people and technology. Moreover, behavioural aspects (from people) are magnified by the type of information needed for exchange and the methods available for use.

8.2.2 Adopting a New System

The main thing that has been discussed in this thesis is the use of technology as a method of communication to improve the exchange of information between stakeholders. As seen in Chapters Five and Six, these involve people who have been interacting with each other and with the information to deliver the planned project with consideration of the external site concepts. Adopting new technology or techniques require a change in the way people communicate and handle information. Chapters Three, Five and Six shows that the main role involved in managing the flow of information in construction site offices is the project manager who shapes the way it is used, adopted and delivered to stakeholders. However, it is essential to provide training and information access to everyone who needs that information. Thus, communication management on the construction site is part of the main contractor's project management across the whole organisation. This means that the decision to adopt new methods is a complex process that is not only controlled or chosen by the team on site but by the top management of the organisation. It is formed of the interdependent roles of the main contractor, client, project manager and competitive industry; these parties interact, maintain distributed control and adopt. The predictability of the behaviour of each individual within each stakeholder (subcontractor) group is very low as it is dependent on the relationships and contextual factors of their organisation. However, the aspiration of project managers is to change the method of information management to one that could be controlled, to some extent, with the support of top management from the main contractor organisation. Adopting new technology to exchange information can be effective in bridging potential gaps between the project stakeholder methods. Further detail on the challenges in using new technology to communicate and exchange information were mentioned in Chapters Three, Five and Six. The main issues were differing generational preferences in working practices and the mentality associated with the refusal of change. To overcome these challenges, it is important to consult and incorporate the experience and knowledge of each generation. This could be used to ease the information flow and reduce the defects that could arise in construction projects.

Another important consideration to improve the quality of communication and information exchange is to keep up to date in the competitive industry. A construction site has multiple options for technology, which could all enable the successful completion of the required tasks. Thus, one of the challenges that construction sites face is to decide the best option to select. However, the final decision lies with the management of the contractor or sometimes with the client who may ask for the use of specific applications and technology. In these cases when the client knows that they want; therefore, their knowledge and experience could facilitate the

selection of the most suitable technology. The client and top management have a say on what technology to buy and what method to follow; thus, many things reflect on this decision. One of the biggest challenges is the range of options from which to select; as such, this decision depends on the cost, the size of the contractors involved, the size of the project, and the number of employees. The open door policies of both top management and the client help to resolve problems related to the exchange of information, enabling decision-making and the selection of method and technology. Other important issues to consider are the need to accept change, and to look for alternative methods. This includes the management and leadership methods used in the organisation.

Throughout the previous chapters, the research stated the centrality of people, confirming the importance of selecting appropriate team members and subcontractors. Selecting an active team who are open to adopt new methods and to suggest changes to improve the quality of a project can influence top management decisions, which may not meet the needs of the site. Continuous learning and improvement is essential to keep up to date information, which helps to develop members' skills and personalities. The case studies found that top management does not focus on daily activities or technical issues unless they affect the project cost and time.

8.3 Summary

The previous section explains the findings of this research and triangulates the data to validate the result. This has shown that, by revisiting the frameworks from Chapters Three and Four, similar concepts and challenges are apparent, which increases the credibility of the research. In this research, technology, people and organisation, and information flow are linked using communication methods and processes. Understanding the link between these aspects could be useful when adopting new technology, which can be achieved by checking:

- The understanding of the need for technology
- The size of the organisation, the size of the project, and the ability of the team.
- The size of the potential subcontractor.
- The understanding of the information flow in the organisation.
- The ability of any existing technology.

8.4 Revisiting the Aim and Objectives

The research aimed to understand the obstacles, difficulties and challenges of communication and the exchange of information on site from the perspective of the main contractor in order to develop a set of recommendations. This has been achieved through the achievement of the

research objectives (shown in Table 8-1) with the corresponding research stages and thesis chapters.

Objective	Research stage	Thesis chapter
To understand the current communication practices and theories applied on construction sites.	The theoretical understanding was based on a critical literature review. The practical understanding was based on the primary data collection.	Theoretically addressed in Chapter Two. Practically addressed in Chapters Five and Six in which the observations and questionnaires were outlined.
To investigate and identify aspects that help to improve communication and information management, including its access and delivery, according to the main contractor on construction sites.	The study was based on case studies supported by a questionnaire, which was analysed for meaning.	In the literature review in Chapter Three. Then in Chapters Five, Six and Seven to highlight the result of case studies
To investigate and identify aspects that help to improve communication and information management, including its access and delivery, according to the main contractor on construction sites.	This was explored in more detail through the questionnaire and observations	Chapters Five and Six where data were analysed and explained.
To explain the challenges to the establishment of effective communication that consider its complexity based on technology tools applied the UK	This was the third level of interpretation where meaning was made from the data	Chapter Six and the first part of Chapter Seven
To synthesise the findings into a set of recommendations.	Taking a holistic view of the thesis as a whole	Summarised in Chapter Seven in accordance with the rest of thesis chapters.

Table 8-1 Re-visiting the Research Objectives.

8.5 Revisiting the Research Questions

This section reviews the research questions raised at the start of the study, and the outlines the responses

- What are the current communication processes of on-site offices in the UK, including their limitations, challenges and benefits?

The methods and processes of sharing information on site highlight the limitations, which are linked to many factors. The main challenge concerns people and the expected results from improving communication onsite. The research answered this question on the literature review and was supported by the data outcome. The following question was answered in two parts;

- *What is the nature of any communication gap?*
    - *How is it linked to issues concerning information and communication technology?*

The link between communication, information and technology were discussed in Chapter Two. The research stated that communicating information requires considerable management, and communication plays a key role in the flow of information. Further examples were offered using the support of case studies in Chapters Six and Seven. A large amount of information accompanies the complexity of a project, and challenges arise in the effective delivery of that information. The techniques and technology used to communicate the information add meaning by directing the receiver to a particular understanding.

    - *What proportion of the problems relate to technology?*

The researcher found that technology alone cannot solve problems and improve the quality of any information exchange. However, using the right technology in the most effective way made a difference to the outcome by easing the communication and delivery of appropriate information to stakeholders. The use of technology was discussed in Chapter Three and linked with the case studies for a deeper, context specific understanding.

- *How do the stakeholders involved collaborate to enable communication and information exchange?*

In this thesis, the effect of people has been stated in the literature review in Chapter Three, and supported in Chapters Five and Six. The main role involved in the management of communication on site is the project manager. However, without the support and collaboration of other stakeholders the exchange of site information could be at best ineffective or at worst

disastrous. Ensuring a level of trust helps to reduce disputes and conflict. The research found that people play a key role in communication as they decide the information to be shared, the way to share it, and the person who receives it.

- *How could a complex construction environment reflect in the communication on site?*

Many other aspects influence communication on site, including the industry's nature, the complexity of the project, the management system and top management's approach to decision-making. The project details have a massive impact on the information flow and communication methods on site; for example, having an open door policy office on site helps to improve face-to-face communication as it encourages stakeholders to engage in the same place of work.

- *How can construction site teams be supported in the rapid the use of technology, and mobile technology, in particular?*

The relationships between team members are highly dependent on their personalities and the level of trust between stakeholders. Engaging with stakeholders who are trusted means maintaining a recommended list of subcontractors. This helps to both maintain and improve relationships and communication. Having regular training and a single policy when adopting new methods help the team to propose improvements in the use of technology. Site B's team evidenced this when they suggested the adoption of an application for use on site. Furthermore, they raised the issue with top management through suggestions and solutions to support their ideas. This better enabled effective decision-making.

8.6 Contribution to Knowledge

Through the literature review, this research synthesised a significant body of knowledge that identified the key challenges to effective communication in the AEC industry, and particularly within construction site offices. In particular, the following were established;

- The challenges to effective communication on a construction site from the perspective of the main contractor have been identified.
- The potential for technology to enhance the effectiveness of communication and information exchange in construction site offices.

- A list of recommendations to consider when adopting new technologies on construction sites.
- The impact of the challenges to communication for on site office teams.

The findings of this research could help UK construction site offices to;

- Understand the importance of selecting the most appropriate method of communicate and its reflection on both the team and information exchange.
- Understand the importance of team members in the exchange of information and in managing the project.

This research contributes to existing knowledge by proposing a set of recommendations for effective communication through technology in on site offices. This helps to improve the existing understanding of the relationship between communication, people and their organisations, information and technology. The main contractor could also use this research to understand communication on their other sites.

8.7 Validation

In this study, the effective communication challenges in construction site offices have been studied and the following three key aspects of communication were identified; information flow; people and organisation relationship and behaviour; and technology. The link between these aspects defines communication on site. This argument has been validated through triangulation by comparing the literature with the data from the survey and cases studies. Therefore, in this research, technology, organisations and people, and information on site are linked with the information flow through the communication processes. The results show that, in order to adopt new technology on site, key aspects of the team and information that influence the communication process need to be identified in order to ensure the effective use of any existing technology. This research addresses the need to improve communication in a complex environment, such as a project site. Moreover, this outcome can be contextualised in terms of the construction body of knowledge and could serve as a reference point for future research in the field of BIM in an integrated, structural information management system.

8.8 Research Limitations

A research study is an attempt to gain an understanding of a specific area; however, even if the main aims of the research are met and the objectives are fulfilled, there is still scope for improvement, as limitations will exist. In this study, there are a few limitations, such as the

lack of previous research linking the information flow, technology and people in the concept of communication. The research focused on the data collected from a questionnaire, interviews and observations, which supplemented the information gathered from the literature review. Geographic limitations exist in the results as the data for this research were only collected from the UK and just two sites were selected for the observations, which is considered a small example. Moreover, both locations were building projects based in Manchester, so the findings of this study may not be valid at other locations.

The data collection was limited to the participants who shared in the time available. The questionnaire had its limitations concerning access and the answers provided. This could be improved through a better ascertainment of the participants' job titles, as most ignored this part. Finally, time limitations restricted this research as the observations took place on two construction sites over a limited period of time. Therefore, the research could not cover in detail all the aspects related to communication, as these were changeable. Finally, the results of this research were limited to the data collected and do not reflect an overview of the area. Therefore, the applicability of this research to other disciplines has not yet been investigated.

8.9 Future Research

Several ideas relating to potentially interesting and relevant research issues were encountered during the course of this study, but constraints arose that prevented further exploration. Future research could continue the investigation of this study through the adoption of a larger sample size for the interviews or other specific case studies. Such actions could strengthen the existing results. A repetition of this study in other geographical locations could help to define the difference between cultures and communication. Further studies related to the challenges of this research could be undertaken, which could help to further improve the reliability of the findings from this study.

Technology and the Internet influence the rapid changes associated with the industry; thus, studying such new relationships and existing communication channels in construction could help to understand and reduce complexity in the industry. Moreover, the psychological aspects of the construction team remain a critical issue in the management of relationships and communication and would benefit from further exploration. Future research could address these issues either through developing technological solutions or through conceptual frameworks or guidelines.

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Appendix A: Questionnaire questions

The main aim of this survey is to understand the way site information is communicated and to what extent mobile technology has been used and what the communication barriers are.

1. Which of the following describes the nature of your organisations work?

Construction main contracting

Construction sub-contracting

Construction consultancy

Project management

Client

Other please specify.

2. What is the size of your company? (number of employees) Please add your job title as a comment.

>2000

<1000

<500

<100

<50

Other

3. On a single site, how many operatives are currently on site?

4. Do you feel information is communicated adequately on site?
   Yes
   No…. please explain

5. Mostly, why would you require more information? Why is the information that you have received is inadequate? Please give more details as a comment

Missing information
Unclear information
Too much information
Duplicated information
Unresolved
Not up to date information
Incorrect information
Other

6. Do you consider that information distributed to operatives on the site is enough to do their tasks? Please give more details.

Yes
No
More details

7. How knowledgeable are you about the works taking place at the same time as yours?
   From 1-10

8. do you receive information about associated activities that could possibly affect the work that you are conducting? Please give more details.
   Yes
   No
   other

9. What are the standard forms that you have used and how effective are they?

10. Nature of sent information on site

Form or report

Networked electronic databases

Image

Verbal by phone or by visiting the site office

Drawing

other

11. What means of communication do you use to get required information?

Site board

Printed text

Computer Graphic

Printed Graphic

Phone or tablet graphic

Call

Message

Email

Document control system

Mobile apps / name of it

Other

12. How would you be informed of the significant changes on the site?

Type of change / Way to deliver it	Task change	Environment change	Scope of work	Health and safety issues	Work patterns	Design change	Project plan
Written text							

Arranged meeting							
Video conferencing							
Hard copy documents							
Computer Graphic							
Printed Graphic							
Mobile/tablet graphic							
Phone call							
Internal document control system							
External Document control system							
Email							
Message							
Voice mail							
Mobile apps							
Other							

13. Sources of Received Information on Sites and the way to deliver it

	Supervisor	Client	Consultant	Design Team	Sub-contractor	Engineer	Supplier	Project Manager	Quantity Surveyor	Other
Office meeting										

Calls										
Printed documen										
Messages										
Face to face										
Emails										
Doc. Control										
cloud										
Mobile Apps										
Online sharing										
Other										

14. How many times could you visit or call the site office per day?

15. What are the main reasons for visiting the site office, what information requirement are disturbing your activities?

Seeking for information

Design details

Solving site problem

Following task

Plan

Asking for someone

Update the data

Deliver tools

Require tools

Meeting

Waiting decision

Health and safety issues

Asking for someone

Socializing

Other

16. What kind of information could you visit the office site to check? From 1-5

Tender

Construction information

Construction management plans

Correspondences

Records

Meeting and liaison

Programs

Daily work instructions

Commercial+ financial

Quality

Procurement

HSE

Temporary works register

Handover and completion

Other

17. Usually, in what time frame would you need requested information?

Within an hour

Within a day

Within a week

Within the activity time

Immediate

Within the activity time

Other

18. In your opinion, what are the communication barriers?

19. Can you select the tasks Mobile technology is currently being used for?

Daily Diaries

Viewing 2D Drawings

Viewing 3D models

Progress Reports

Snagging

Material tracking

Vehicle tracking

Requests for information/ Technical queries

Document control

H&S monitoring

H&S reporting

Augmented Reality

Early stage planning

Design

Reading emails

None

Other

20. Which factors do you think have the largest impact on improving mobile communication?

Top management support (from 1 to 10)

Training

Continuous support

Perceived usefulness

Perceived Ease of use

Familiarity of interface

awareness of the benefits

health and safety issues

Other

21. Please add any more details that you would like to mention and if possible provide your preferred contact details for further interviews